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ABSTRACT

A job analysis was conducted focusing on the knowledge important for beginning Earth and Space Science teachers. The results of the job analysis will be used to define the content domain of the subject assessment in Earth and Space Sciences for the Praxis series of professional assessments for beginning teachers. A domain of 292 knowledge statements and elements was developed by subject matter experts. These statements and supporting elements were then incorporated into a survey completed by 974 Earth and Space science teachers, teacher educators, and state administrators. These professionals rated the importance of each knowledge statement and element, and those ranking above the midpoint of the scale were considered eligible for the subject assessment. The 36 statements and elements that did not pass the cut point are not recommended for the final version. Emphasis, instead, should be put on the 256 knowledge statements and elements that did pass the cut point. Six tables present study results, and eight appendixes provide supplemental information. (Contains 16 references.) (Author/SLD)

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DEFINING THE CONTENT DOMAIN FOR THE PRAXIS II SUBJECT ASSESSMENT IN EARTH AND SPACE SCIENCE: KNOWLEDGE IMPORTANT FOR BEGINNING TEACHERS

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Educational Testing Service
Princeton, New Jersey
November 1994

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Defining the Content Domain for the Praxis II Subject Assessment in Earth and Space Science: Knowledge Important for Beginning Teachers

Richard J. Tannenbaum
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Abstract

The purpose of this study was to conduct a job analysis focusing on the knowledge important for beginning Earth and Space Science teachers. The results of the job analysis will be used to define the content domain of the Subject Assessment in Earth and Space Science for the Praxis Series: Professional Assessments for Beginning Teachers®.

A domain of 292 knowledge statements and elements (specific descriptors used to clarify the meaning of each, more broadly defined, knowledge statement) was developed by subject-matter experts. These statements and elements were then incorporated into a survey that was administered to a large number of Earth and Space Science teachers, teacher educators, and state administrators. These professionals rated the importance of each knowledge statement and knowledge element using a 0- to 4-point scale.

A cut point of a mean of 2.50 (midpoint between moderately important and important) was established to differentiate important knowledge ($\underline{M} \geq 2.50$) and unimportant knowledge ($\underline{M} < 2.50$). The results indicated that a total of 36 knowledge statements and knowledge elements (12% of the total domain) failed to pass the cut point. It is recommended that these 36 statements and elements not be included in the development of the Subject Assessment in Earth and Space Science; emphasis, instead, should be put on the 256 knowledge statements and knowledge elements that did pass the cut point.

Introduction

The Praxis Series: Professional Assessments for Beginning Teachers® offers assessments for each stage of the beginning teacher's career, from entry into teacher education to actual classroom performance (Educational Testing Service, 1992). The Praxis Series can be used by state agencies as one of several criteria for initial teacher licensure. The subject assessments for The Praxis Series are designed to assess a teacher candidate's subject-matter knowledge and, where appropriate, knowledge about and skills or abilities for teaching that subject matter. These assessments are based, in part, on the premise that competent beginning teachers should demonstrate an understanding of the subject matter they intend to teach (Grossman, Wilson, & Shulman, 1989) and demonstrate knowledge of teaching principles and strategies specific to the subject matter (Grossman, 1989; McDiarmid, Ball, & Anderson, 1989; Reynolds, 1992).

The Subject Assessment in Earth and Space Science will offer a multiple-choice core test and a constructed-response module. The multiple-choice test will cover basic knowledge, application of principles, analysis of complex situations, and the ability to synthesize information. The constructed-response module will cover content knowledge and specific scientific skills.

Purpose of the Study

The purpose of this study was to conduct a job analysis focusing on the knowledge important for beginning Earth and Space Science teachers. The results of the job analysis will be used to define the content domain of the Subject Assessment in Earth and Space Science. Because validity inferences associated with licensure (and certification) tests are based primarily on content-related evidence, the inclusion of a well-designed job analysis in the test development process is essential (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 1985).

Job analysis refers to procedures designed to obtain descriptive information about the tasks performed on a job and/or the knowledge, skills, and abilities thought necessary to perform those tasks (Arvey & Faley, 1988; Gael, 1983). The specific type of information collected for a job analysis is determined by the purpose for which the information will be used. For purposes of developing licensure (and certification) tests, a job analysis should identify the important knowledge, abilities, or skills necessary to protect the public--interpreted as the importance of the test content for competent performance in an occupation (American Educational Research Association et al., 1985). In addition, it is recommended that a job analysis include the participation of various subject-matter experts (Mehrens, 1987) and that the information collected be representative of the diversity within the occupation (Kuehn, Stallings, & Holland, 1990). Diversity refers to regional or job context factors and to subject-matter-expert factors such as race or ethnicity, experience, and sex. The job analysis conducted to support the content-related validity of the Subject Assessment in Earth and Space

Science was designed to be consistent with the *Standards for Educational and Psychological Testing* (American Educational Research Association et al., 1985) and current professional practice.

Objectives of the Study

The objectives of this study were: (a) to have subject-matter experts define a domain of knowledge statements and knowledge elements -- henceforth referred to as knowledge components or components, collectively -- that they believed was important for the competent performance of beginning Earth and Space Science teachers and then (b) to have a national sample of Earth and Space Science professionals (i.e., teachers, teacher educators, and state administrators) verify or refute the importance of the knowledge components. The latter objective is accomplished through the administration of a job analysis survey and serves as an independent check, by a wide range of professionals, on the relevance of the domain to the competent performance of a beginning Earth and Space Science teacher. This independent check reduces the likelihood that unimportant knowledge components will be included during the development of the Subject Assessment in Earth and Space Science. Components that are verified to be important may be used in the development of the Subject Assessment in Earth and Space Science.

Method

Overview

The methodology consisted of defining the knowledge components important for beginning Earth and Space Science teachers to perform their jobs in a competent manner. To accomplish this, subject-matter experts first identified major content areas of subject-matter knowledge, e.g., Tectonics, The Rock Cycle. These content areas formed the overall structure of the knowledge domain. Next, within each content area, the subject-matter experts defined specific knowledge components. As stated previously, the knowledge components were knowledge statements and knowledge elements. The statements represented intact, operational knowledge; the elements clarified the scope of the statements and were to be interpreted in the context of its respective knowledge statement, and not as an isolated (stand-alone) element. The domain was then presented to the national sample of Earth and Space Science teachers, teacher educators, and state administrators for verification or refutation. The names of the teachers and teacher educators were obtained from the database maintained by Market Data Retrieval Services (MDRS), a survey research organization. This database contains the names of over 90% of all public school teachers and teacher educators in the United States. The names of the state administrators were obtained from the membership directory of the Council of State Science Supervisors. The survey participants were asked to rate the knowledge components in terms of their importance for the competent performance of beginning Earth and Space Science teachers. The specific steps in the job analysis process are described below.

Building Draft Domain of Knowledge

The first step in the job analysis was to construct preliminary knowledge content areas and knowledge components. This draft domain would function as the initial definition of knowledge important for the competent performance of beginning Earth and Space Science teachers. Three draft knowledge domains were developed. Each draft represented a different organization of the domain of knowledge. These drafts were constructed by Educational Testing Service (ETS) Test Development staff with subject-matter expertise in Earth and Space Science and ETS Research staff with expertise in job analysis. In the process of developing these drafts, the ETS subject-matter experts reviewed NTE Earth and Space Science test specifications, state science requirements, recently published college and secondary level textbooks, and other relevant professional literature.

Each of the three draft domains was reviewed by three Earth and Space Science teachers, two secondary school teachers and one middle school teacher (see Appendix A). These teachers were asked to select the draft that they believed best represented the domain. The teachers unanimously selected he draft that depicted an integrative organization of the knowledge domain; they believed that this accurately represented the current thinking in the teaching of Earth and Space Science. This draft domain consisted of six major content areas partitioned into various subareas and 515 knowledge components. The content areas were: (a) Basic Scientific Principles, (b) The Water Cycle, (c) The Rock Cycle, (d) Earth's Biography, (e) Plate Tectonics, (f) The Earth in Space.

Review of Draft Domain by External Review Panel

After the draft domain was constructed, it was mailed to a panel of nine external subject-matter experts, five secondary school teachers, two teacher educators, and two administrators (see Appendix B). The panel members were identified by the ETS Test Development staff. The panelists were selected for their content expertise, their involvement with teacher education and development, and for their diversity with respect to sex, geographic region, and race or ethnicity.

The purpose of the External Review Panel was to critique the draft domain in terms of: (a) the appropriateness of its overall structure (defined by the six major content areas) and (b) the appropriateness of the specific knowledge components in terms of their relevance to the competent performance of beginning Earth and Space Science teachers. The panelists were asked to recommend specific modifications to the domain (i.e., additions, deletions, reorganizations, wording changes) so that it reflected what they believed to be a domain that sufficiently covered the knowledge important for beginning Earth and Space Science teachers.

The recommendations of the panelists were obtained via telephone interviews conducted by ETS Research staff. The individual recommendations were compiled and discussed with ETS Test Development staff. The compiled

recommendations were presented as an additional source of information during the Advisory/Test Development Committee meeting (see below). In general, the panelists believed that the number of knowledge components should be reduced. Components were identified for potential deletion either because they were believed to overlap with other components or because they were not believed to be relevant to the competent performance of a beginning Earth and Space Science teacher. Other recommendations focused on making wording changes to clarify meaning.

Advisory/Test Development Committee Meeting

Evidence in support of content-related validity is enhanced by the inclusion of large numbers of subject-matter experts who represent the relevant areas of content expertise (Ghiselli, Campbell, & Zedeck, 1981). This job analysis study was designed, therefore, to obtain input from many subject-matter experts throughout the domain definition process. In addition to the External Review Panel, an Advisory/Test Development Committee of six Earth and Space Science professionals (four secondary school teachers and two teacher educators) was formed (see Appendix C). This committee also had representation by sex, geographic region, and race or ethnicity.

The purpose of this committee was similar to that of the External Review Panel--to critique the draft domain in terms of the appropriateness of its overall structure and the appropriateness of the knowledge components. The committee members were asked to revise the domain consensually (to add, delete, or reorganize content, and to make wording changes) so that it reflected what they collectively believed to be a domain that covered the knowledge important for beginning Earth and Space Science teachers. The committee members also reviewed and approved the rating scale of importance to be used in the national survey as well as the biographical information that would be asked of the survey participants. The biographical data are used to describe the composition of the Earth and Space Science professionals who return usable surveys and to permit the analysis of the judged importance of the knowledge components by various subgroups of Earth and Space Science professionals (e.g., males and females).

The revision of the draft domain occurred during a two-day meeting. The meeting was led jointly by ETS Test Development and Research staff. Prior to the meeting, the committee members had been mailed copies of the draft domain to review. The members had been informed about the purpose of the meeting and had been asked to come prepared to discuss their reviews of the draft domain. A computer was used during the meeting to make on-line changes to the domain as discussion occurred; at appropriate points of discussion, the compiled recommendations of the External Review Panel were presented. A projection of the revisions onto a large screen facilitated the revision process and helped to ensure the accuracy of the revisions. The revised domain consisted of 292 knowledge components clustered within the following major content areas: (a) Basic Scientific Principles, (b) Tectonics, (c) The Rock Cycle, (d) History of the Earth, (e) The Water Cycle, and (f) The Earth in Space.

After the meeting, the revised domain was presented to the committee members for individual review. The members were asked to take the domain home with them and to mail their recommendations for modification, if any, back to ETS. With the exception of some minor wording changes, no modifications were suggested.

Job Analysis Survey

As described previously, a job analysis survey was included to serve as an independent verification or refutation of the judgments of the subject-matter experts. The use of a survey facilitates obtaining judgments of domain importance from large numbers of Earth and Space Science professionals; and basing test content decisions on these collective judgments reduces the likelihood that unimportant knowledge components will be included in the development of the Subject Assessment in Earth and Space Science. The use of a survey also helps to reinforce the fairness and relevance of the test content to the diversity of teacher candidates. This is accomplished by computing mean importance ratings by different groups (e.g., teachers and teacher educators) and subgroups (e.g., geographic region, sex) of survey respondents. Knowledge components judged to be important by all groups and subgroups are targeted for inclusion in the Subject Assessment in Earth and Space Science.

The job analysis survey (see Appendix D) consisted of three parts. Part I included the six major content areas and 292 knowledge components. The respondents were asked to judge the importance of each knowledge component using a two-step, 0- to 4-point scale:

1. Evaluate the importance of each *italicized* knowledge statement for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers.

2. Evaluate the importance of each knowledge element in the context of its respective *italicized* knowledge statement.

0	1	2	3	4
Of no importance	Of little importance	Moderately important	Important	Very important

In addition, the overall importance of each major content area was judged using the same 0-to-4 rating scale anchors. The two-step importance rating scale was approved by the members of the advisory committee; its emphasis on importance is consistent with the guidelines of the *Standards for Educational and Psychological Testing* (AERA et al., 1985) for defining content domains for licensure tests.

Part I also allotted space for survey respondents to add knowledge content areas as well as knowledge components that they believed should be included in the domain. In addition, the respondents were asked to rate how well the knowledge statements within a major content area covered the important aspects

of that major content area. This provided an indication of content coverage. The rating scale was anchored by the following five points: (1) Very Poorly, (2) Poorly, (3) Adequately, (4) Well, and (5) Very Well.

In Part II of the job analysis survey, the respondents were asked to indicate the percentage of test items that they believed should be included for each of the six major content areas. The respondents were asked to do this by distributing a total of 100 points (test items) across the six content areas.

Part III was the background information section. The survey respondents were asked to answer several questions that described their demographic makeup (e.g., teaching experience, sex, race or ethnicity). This information was used to describe the survey respondents and to perform relevant subgroup analyses.

Pilot Test of the Job Analysis Survey

Prior to the large-scale administration, the job analysis survey was pilot tested on five Earth and Space Science professionals: four teachers and one teacher educator. These professionals were asked to complete the survey and to respond to a debriefing questionnaire. The participants did not report any difficulties completing the survey, which took an average of 50 minutes.

Administration of the Job Analysis Survey

The job analysis survey, accompanied by a letter of invitation to participate (see Appendix E for a copy of the letter), was mailed to a random sample of 990 Earth and Space Science professionals: teachers (n = 600), teacher educators (n = 300), and state administrators (n = 90). These distributions represent the selection of approximately 12 teachers, 6 teacher educators, and 2 state administrators from each state and the District of Columbia. The teachers and teacher educators were randomly selected from the database maintained by Market Data Retrieval Services (MDRS), a survey research organization. The state administrators were obtained from the membership directory of the Council of State Science Supervisors. One week after the surveys were mailed, a follow-up postcard was mailed to all the Earth and Space Science professionals reminding them to complete and return their job analysis surveys.

Analysis Plan

Primary Analyses

Mean importance ratings, standard deviations (SDs), and correlations of the profiles of mean importance ratings were to be computed by different groups (teachers, administrators, and teacher educators) and subgroups (race or ethnicity, sex, geographic region, and teaching experience) of survey respondents. To be included in these analyses, however, each group and subgroup was required to have at least 30 respondents (e.g., ≥ 30 teacher

educators, ≥ 30 females). This minimal number is necessary, according to Walpole (1974), to increase the probability that the computed mean values are accurate estimates of the corresponding population mean values.

The computation of means is used to determine the absolute level of importance attributed to the knowledge components by the survey respondents. The mean analysis is used to establish a cut point to differentiate important and unimportant knowledge components. It is with respect to this cut point that test content inclusion decisions are made. Components for which the mean importance rating meets or exceeds the cut point value for all groups and all subgroups of survey respondents are considered for inclusion in the development of the Subject Assessment in Earth and Space Science.

The computation of correlations is used to determine intergroup (e.g., teachers-teacher educators) agreement and intrasubgroup (e.g., male-female) agreement with respect to the relative importance of the knowledge components.

Cut Point of Mean Importance

Since the purpose of job analysis is to ensure, to the extent possible, that only the more important knowledge components are included in the development of the Subject Assessment in Earth and Space Science, a cut point for content inclusion needs to be established. Previous job analysis studies (Reynolds, Tannenbaum, & Rosenfeld, 1992; Tannenbaum, 1992a, 1992b) that similarly defined content domains for other Praxis Series subject assessments used a cut point of a mean importance rating of 2.50 (midpoint between moderately important and important). That is, domain components (knowledge, skills, and/or abilities) with a mean importance rating equal to or greater than 2.50 were classified as important (passed the cut point); and components with a mean importance rating of less than 2.50 were classified as unimportant (failed to pass the cut point). This same cut point value of 2.50 was used in the present study.

It should also be noted that, similar to the previous job analysis studies, a caveat to the strict application of the cut point was introduced. Because survey respondents were not involved in the development of the knowledge domain, they may lack certain insights that the Advisory/Test Development Committee members have because of their high level of involvement in the definition of the domain. As a consequence, if the committee members believe that a knowledge component rated below 2.50 should be considered for inclusion in the development of the Subject Assessment in Earth and Space Science, and the members can provide *compelling written rationales*, that knowledge component may be reinstated for inclusion. The latitude given the committee members in making final test content decisions is consistent with recommended professional practice. Madaus and Mehrens (1990) have clearly stated that the results of a job analysis survey should influence final decisions but should not force the decisions, and that final decisions should be left to the committee members.

Secondary Analyses

Means and SDs were to be computed for the ratings of both content coverage and content emphasis. The former provides an indication of the comprehensiveness of the domain of knowledge components. The latter provides an indication of the weight that the six major content areas should receive on the Subject Assessment in Earth and Space Science. These values were to be computed for teachers, administrators, and teacher educators.

Results

Survey Respondents

Response rate. Of the 990 total job analysis surveys that were mailed, 11 were returned because of an invalid mailing address, and 5 were returned after data analysis had already been completed. The response rate, adjusted for these 16 surveys, was 32% (308/974).

Demographic characteristics. On average, 285 respondents completed the background information section of the job analysis survey. Of those providing background information, 73% were male, 88% were White, 62% were certified in Earth Science, and 53% had 11 or more years of teaching experience. The largest proportion (61%) were teachers; and 28% were college faculty (teacher educators). Only 6% (n = 19) of the respondents identified themselves as state-level administrators. Appendix F provides a complete description of the respondent demographics.

Importance Ratings: Analysis of Means

Aggregate of survey respondents. Means and SDs were computed for the 292 knowledge components by the total number (n = 308) of survey respondents. This level of analysis provides an overall description of the perceived importance of the knowledge components. The means ranged from a low of 2.22 (~ moderately important) to a high of 3.74 (~ very important); 6.5% (n = 19) were between 4.00 and 3.50; 22.3% (n = 65) were between 3.49 and 3.25; 31.8% (n = 93) were between 3.24 and 3.00; 34.9% (n = 102) were between 2.99 and 2.50; and 4.5% (n = 13) were less than 2.50. The average standard deviation for the profile of 292 knowledge components was 0.81 (minimum SD = 0.49, and maximum SD = 1.07).

Teachers and teacher educators. Table 1 presents the means and SDs for each of the six content areas by teachers and teacher educators. (Too few administrators, i.e., < 30, responded to the survey to be included in any of the analyses.) All the content areas were judged to be important. For the teachers, Tectonics received the highest mean rating (M = 3.51) and The Earth in Space received the lowest mean rating (M = 3.16). For the teacher educators, Basic Scientific Principles received the highest mean rating (M = 3.63) and, similar to the teachers, The Earth in Space received the lowest mean rating (M = 2.94).

Table 1

Overall Mean Importance Ratings for Each of the Six Major Content Areas by Teachers and Teacher Educators

	Teachers		Teacher Educators	
Major Content Areas	Mean	SD	Mean	SD
Basic Scientific Principles	3.37	0.64	3.63	0.54
Tectonics	3.51	0.61	3.56	0.59
The Rock Cycle	3.38	0.67	3.43	0.67
History of the Earth	3.18	0.74	3.54	0.59
The Water Cycle	3.42	0.63	3.44	0.64
The Earth in Space	3.16	0.78	2.94	0.84

Means and SDs were also computed for each of the 292 knowledge components for teachers and teacher educators. These values are presented in Appendix G. Those components with a mean importance rating lower than the cut point of 2.50 are displayed in Table 2 (each knowledge element needs to be interpreted in the context of its respective *italicized* knowledge statement). In total, 34 knowledge components (12%) had a mean rating of less than 2.50 across the teachers and teacher educators. Seventeen of these 34 components (50%) were rated below 2.50 only by the teacher educators; 8 components (24%) were rated below 2.50 only by the teachers; 9 components (26%) were rated below 2.50 by both groups.

Table 2

Knowledge Components with Mean Importance Ratings Below 2.50 by Teachers and Teacher Educators

Knowledge Components	Teachers	Teacher Educators
5.3 national/local databases		2.35
9.1 spreadsheets	2.44	
9.3 simulations including videodisc and CD-ROM		2.43
9.5 accessing national databases and on-line services	2.38	2.41
10.6 types and rates of chemical reactions	2.44	
13.6 laws of thermodynamics	2.47	
13.9 kinetic molecular theory		2.38
14.1 historical development of atomic models	2.16	2.26
15.1 nuclear forces and binding energy	2.40	
15.3 artificial and natural radiation	2.41	

21.4	Van Allen belts	2.49	2.07
21.5	auroras		1.99
27.4	types of soil		2.42
44.8	power generated by wind		2.35
44.9	weather modification (e.g., cloud seeding, hail suppression)		2.18
46.6	hydro(electric) power		2.35
46.9	recreational use and aesthetic considerations		2.27
47.4	chemical cycles (dissolved ions)	2.37	
48.4	reefs and atolls	2.48	
48.6	importance of ocean water at plate boundaries		2.47
51.	*Understand the interrelationships between civilizations and the cryospheres (ice)*	2.48	
51.1	development on permafrost (e.g., Alaskan pipeline)	2.38	2.40
51.2	land bridges	2.37	2.38
51.3	hazards of ice (e.g., icebergs)	2.21	2.09
51.4	ice as a resource	2.24	2.09
56.7	ancient astronomy	2.41	1.94
57.4	H-R diagram		2.27
58.	*Understand the interrelationships between civilizations and astronomical objects*		2.34
58.1	constellations and star charts		2.09
58.2	space exploration		2.41
58.3	planetariums		1.96
59.1	multiple star systems (e.g., binaries, clusters)		2.33
59.2	characteristics of galaxies		2.48
59.4	quasars	2.44	2.22

Subgroups of survey respondents. In order to support the fairness and relevance of the test content to the diversity of teacher candidates, means were computed for appropriate subgroups of survey respondents: geographic region, sex, and teaching experience (only for respondents who identified themselves as teachers). Subgroup analyses were not conducted by race or ethnicity because of the small numbers of non-White respondents (i.e., < 30). The mean importance ratings across all subgroups are presented in Appendix H.

Those knowledge components with a mean importance rating lower than the cut point of 2.50 are displayed in Table 3 (see page 14). In total, 28 knowledge components (10%) had a mean rating of less than 2.50 across the different subgroups of survey respondents. Of these 28, 26 were "flagged" by the analysis of the mean responses of the teachers and teacher educators. The

two additional components flagged by the analysis of the subgroup responses were: knowledge statement 3 -- "*Demonstrate knowledge of historical roots of science and the contributions made by major historical figures as well as members of cultural/ethnic groups*"; and knowledge element 59.5 (under *Understand the structure of the Milky Way and other galaxies*) -- structure of the universe. It should be noted that both of these flagged components were rated below 2.50 only by respondents from the central region of the country.

Importance Ratings: Correlational Analyses

Teachers and teacher educators. The correlation between the profiles of mean importance ratings (n = 292 knowledge components) for teachers and teacher educators was .76. This indicates a moderately high degree of agreement between the two groups in terms of the relative importance of the knowledge components.

Subgroups of survey respondents. Pairwise correlations of the profiles of mean importance ratings (n = 292 knowledge components) were computed within the different subgroups. For example, within the subgroup of sex, the profile of means for males was correlated with the profile of means for females. The correlation values for all the subgroups are presented in Table 4. There was a high level of agreement in terms of the relative importance of the knowledge components within each of the subgroups of respondents; the average correlation (Fisher Z-transformed) was .92.

Table 3

Knowledge Components with Mean Importance Ratings Below 2.50 by Geographic Region, Sex, and Teaching Experience

		Geographic Region				Sex		Teaching Experience	
	Knowledge Components	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
3.	*Demonstrate knowledge of historical roots of science and the contributions made by major historical figures as well as members of cultural/ethnic groups (e.g., ancient Chinese and Greek astronomers, Galileo, Darwin, Curie, Hutton)*		2.40						
5.3	national/local databases		2.47	2.48	2.41		2.46	2.40	
9.1	spreadsheets		2.47	2.49					
9.5	accessing national databases and on-line services	2.48	2.38				2.43	2.44	2.45
10.6	types and rates of chemical reactions			2.43					
13.9	kinetic molecular theory			2.48					
14.1	historical development of atomic models	2.12	2.15	2.30	2.35	2.10	2.25	2.37	2.19
15.1	nuclear forces and binding energy	2.40	2.40			2.45		2.48	
15.3	artificial and natural radiation		2.42					2.40	
21.4	Van Allen belts	2.34	2.46	2.46	2.36		2.33		2.35
21.5	auroras	2.35			2.32		2.38		2.37
44.9	weather modification (e.g., cloud seeding, hail suppression)	2.47			2.43		2.39		2.45
46.9	recreational use and aesthetic considerations		2.45		2.43		2.47		
47.4	chemical cycles (dissolved ions)	2.47	2.43			2.49			2.45
48.4	reefs and atolls		2.48						
48.6	importance of ocean water at plate boundaries		2.42						
51.	*Understand the interrelationships between civilizations and the cryospheres (ice)*							2.45	
51.1	development on permafrost (e.g., Alaskan pipeline)	2.49	2.43	2.44	2.46		2.38	2.38	2.48
51.2	land bridges	2.44	2.42	2.47			2.38	2.40	2.47

NOTE. NE = Northeast; C = Central; S = Southern; FW = Far West

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Table 3 (cont.)

51.3	hazards of ice (e.g., icebergs)	2.24	2.33	2.21	2.19	2.36	2.20	2.23	2.25
51.4	ice as a resource	2.30	2.33	2.20	2.24	2.41	2.22	2.20	2.29
56.7	ancient astronomy	2.41	2.23	2.39	2.11	2.38	2.24	2.38	2.27
57.4	H-R diagram		2.49						
58.1	constellations and star charts				2.30		2.43		
58.3	planetariums	2.44	2.48		2.23		2.35		2.40
59.1	multiple star systems (e.g., binaries, clusters)				2.44		2.47		
59.4	quasars		2.35	2.42	2.27	2.46	2.36	2.44	2.39
59.5	structure of the universe (e.g., curvature, gravitational/time relationships)		2.39						

Table 4

Correlations of the Profiles of Mean Importance Ratings: Geographic Region, Sex, and Teaching Experience

	1	2	3	4
GEOGRAPHIC REGION				
1. Northeast				
2. Central	.94			
3. Southern	.93	.93		
4. Far West	.90	.91	.92	
SEX				
1. Female				
2. Male	.91			
TEACHING EXPERIENCE				
1. ≤ 6 years				
2. ≥ 6 years	.92			

Mean Ratings of Content Coverage

Teachers and teacher educators indicated that each of the six major content areas was well covered by its respective knowledge components. All the mean ratings, presented in Table 5, exceeded 4.00 on the 1- to 5-point scale described on page 7.

Table 5

Mean Ratings of Content Coverage

	Teachers		Teacher Educators	
Major Content Areas	Mean	SD	Mean	SD
Basic Scientific Principles	4.26	0.74	4.22	0.74
Tectonics	4.44	0.67	4.27	0.69
The Rock Cycle	4.41	0.66	4.26	0.72
History of the Earth	4.33	0.72	4.15	0.77
The Water Cycle	4.36	0.66	4.36	0.60
The Earth in Space	4.35	0.69	4.12	0.84

Mean Ratings of Content Emphasis

Overall, the teachers and teacher educators agreed on the emphasis that they believed should be put on each of the six major content areas (see Table 6). For both groups, Basic Scientific Principles, Tectonics, and The Rock Cycle received the most emphasis. The standard deviation for Basic Scientific Principles does indicate, however, that there was some disagreement within each group.

Table 6

Mean Percentage Weights

	Teachers		Teacher Educators	
Major Content Areas	Mean	SD	Mean	SD
Basic Scientific Principles	18.54	10.46	19.70	9.14
Tectonics	17.07	5.02	17.59	3.84
The Rock Cycle	16.96	4.83	17.64	4.52
History of the Earth	13.97	5.07	16.06	4.77
The Water Cycle	16.70	5.44	17.03	4.71
The Earth in Space	16.27	6.31	11.98	5.02

Summary and Conclusion

The purpose of this study was to conduct a job analysis focusing on the knowledge important for beginning Earth and Space Science teachers. The results of the job analysis will be used to define the content domain of the Subject Assessment in Earth and Space Science for the Praxis Series: Professional Assessments for Beginning Teachers®.

A domain of 292 knowledge components was developed by subject-matter experts. These components were then incorporated into a survey that was administered to a large number of Earth and Space Science teachers, teacher educators, and state administrators. These professionals rated the importance of each knowledge component using a 0- to 4-point scale.

A cut point of a mean of 2.50 (midpoint between moderately important and important) was established to differentiate important knowledge ($\underline{M} \geq 2.50$) and unimportant knowledge ($\underline{M} < 2.50$). The results indicated that a total of 36 knowledge components (12% of the total domain) failed to pass the cut point (see Table 2 and components 3 and 59.5 of Table 3). It is recommended that these 36 components not be included in the development of the Subject Assessment in Earth and Space Science; emphasis, instead, should be put on the 256 knowledge components that did pass the cut point. Consideration should only be given to the 36 flagged components if the members of the Advisory/Test Development Committee firmly believe that these components are important enough for reinstatement and can support their decisions with *compelling written rationales*.

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Appendix D

Job Analysis Survey

JOB ANALYSIS INVENTORY

FOR BEGINNING

TEACHERS OF EARTH

AND SPACE SCIENCE

By

Educational Testing Service
Princeton, New Jersey

D3

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INTRODUCTION

The entire knowledge domain represented by this job analysis inventory was carefully developed by ETS in cooperation with several content experts in the field of Earth and Space Science education. These content experts are highly regarded teachers, teacher educators, and state administrators from different regions of the country. All of these experts are actively involved in Earth and Space Science education. This knowledge domain represents what these content experts believe to be knowledge important for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers.

The job analysis inventory for Earth and Space Science consists of six overall content areas: (1) Basic Scientific Principles, (2) Tectonics, (3) The Rock Cycle, (4) History Of The Earth (5) The Water Cycle, and (6) The Earth In Space. Listed under these overall content areas are *italicized* statements of operational knowledge. These *italicized* knowledge statements represent what are believed to be knowledge important for all beginning (newly licensed\certified) Earth and Space Science teachers. Importance is interpreted with respect to the competent job performance of a beginning Earth and Space Science teacher.

Listed under the *italicized* knowledge statements are several knowledge elements. These knowledge elements are meant to clarify the scope of the *italicized* knowledge statement. Therefore, each knowledge element must be interpreted in the context of its respective *italicized* knowledge statement, and not as an isolated (stand-alone) element.

YOUR INVOLVEMENT IN GUIDING THE DEVELOPMENT OF THE SUBJECT ASSESSMENT IN EARTH AND SPACE SCIENCE

We would like to determine if you, as an Earth and Space Science professional, similarly believe that the listed knowledge statements and knowledge elements are important for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers. You, and 1,000 of your Earth and Space Science colleagues, are being asked to make this judgment of importance. Your judgment is critical: those knowledge statements and knowledge elements that you and your colleagues judge to be important will be used to guide the development of the Subject Assessment in Earth and Space Science.

Please use the 5-point importance scale below to make your judgments.

1. **Evaluate the importance of each *italicized* knowledge statement for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers.**

2. **Evaluate the importance of each knowledge element in the context of its respective *italicized* knowledge statement.**

CIRCLE THE NUMBER THAT BEST DESCRIBES YOUR JUDGMENT FOR EACH STATEMENT AND ELEMENT

0	1	2	3	4
Of no importance	**Of little importance**	**Moderately important**	**Important**	**Very Important**

1. **Evaluate the importance of each *italicized* knowledge statement for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers.**

2. **Evaluate the importance of each knowledge element in the context of its respective *italicized* knowledge statement.**

CIRCLE THE NUMBER THAT BEST DESCRIBES YOUR JUDGMENT FOR EACH STATEMENT AND ELEMENT

0	1	2	3	4
Of no importance	Of little importance	Moderately important	Important	Very Important

I. BASIC SCIENTIFIC PRINCIPLES	IMPORTANCE
A. Scientific Methodology and Philosophy	
1. *Understand the methods of scientific problem solving*	0 1 2 3 4
1.1. facts, models, theories, hypotheses, and laws	0 1 2 3 4
1.2. process skills (e.g., problem identification, observation, measurement, inference, classification)	0 1 2 3 4
1.3. investigative and experimental methods	0 1 2 3 4
2. *Understand the importance of the study of Earth and Space Science*	0 1 2 3 4
2.1. the significance of Earth and Space Science in everyday life (e.g., social/environmental issues, aesthetics, recreation)	0 1 2 3 4
2.2. integration of Earth and Space Science in other science fields	0 1 2 3 4
2.3. the interrelatedness of Earth and Space Science and other fields of study (e.g., history, literature, art)	0 1 2 3 4
2.4. careers in Earth and Space Sciences and related fields	0 1 2 3 4
3. *Demonstrate knowledge of historical roots of science and the contributions made by major historical figures as well as members of cultural/ethnic groups (e.g., ancient Chinese and Greek astronomers, Galileo, Darwin, Curie, Hutton)*	0 1 2 3 4
B. Mathematics, Measurement, and Data Manipulation	
4. *Understand the use of various measurement systems*	0 1 2 3 4
4.1. English system	0 1 2 3 4
4.2. metric (SI) system	0 1 2 3 4
4.3. exponential notation	0 1 2 3 4
4.4. map scales	0 1 2 3 4
4.5. significant figures	0 1 2 3 4
4.6. scales specific to Earth and Space Science (e.g., geologic time scales, astronomical distances, magnitudes, logarithmic)	0 1 2 3 4
5. *Compile, evaluate, and interpret data, including analysis of errors*	0 1 2 3 4
5.1. compilation and interpretation of data (e.g., text, graphs, charts, tables, photographs, and maps)	0 1 2 3 4
5.2. analysis and evaluation of data	0 1 2 3 4
5.3. national/local databases	0 1 2 3 4
5.4. observational and experimental variation: sources, precision, accuracy, and experimental error	0 1 2 3 4

I. **BASIC SCIENTIFIC PRINCIPLES (cont.)**	**IMPORTANCE**
6. *Understand and interpret maps and photographs*	0 1 2 3 4
6.1. map projections	0 1 2 3 4
6.2. legends, symbols, and scales	0 1 2 3 4
6.3. aerial and satellite photographs	0 1 2 3 4
6.4. topographic maps including bathymetric maps	0 1 2 3 4
6.5. geologic maps	0 1 2 3 4
6.6. weather maps	0 1 2 3 4
C. Laboratory/Field Procedures and Safety	
7. *Understand the proper methods involved in using laboratory and field materials and equipment in a safe and appropriate manner*	0 1 2 3 4
7.1. use of chemicals and equipment (e.g., acids, glassware)	0 1 2 3 4
7.2. preparation, storage, and disposal of materials	0 1 2 3 4
7.3. safety procedures for laboratory and field work	0 1 2 3 4
7.4. laboratory and field hazards	0 1 2 3 4
8. *Understand the appropriate use of equipment/instruments for measurement and observation in Earth and Space Science*	0 1 2 3 4
8.1. Earth's interior (e.g., seismographs)	0 1 2 3 4
8.2. surface of the Earth (e.g., maps, satellite images, microscopes)	0 1 2 3 4
8.3. oceans and ocean floor (e.g., submersibles, sonar)	0 1 2 3 4
8.4. Earth's atmosphere (e.g., barometers, anemometers)	0 1 2 3 4
8.5. astronomical objects (e.g., telescopes, spectroscopes)	0 1 2 3 4
9. *Understand computer and related technologies as they apply to investigative activities*	0 1 2 3 4
9.1. spreadsheets	0 1 2 3 4
9.2. generation of graphs, maps, and profiles	0 1 2 3 4
9.3. simulations including videodisc and CD-ROM	0 1 2 3 4
9.4. interactive systems: using the computer to collect/analyze data	0 1 2 3 4
9.5. accessing national databases and on-line services	0 1 2 3 4
D. Biological, Chemical, and Physical Processes	
10. *Understand fundamental biological, chemical, and physical processes as they apply to the study of Earth and Space Science*	0 1 2 3 4
10.1. characteristics of life forms	0 1 2 3 4
10.2. evolutionary processes (e.g., natural selection, mutation)	0 1 2 3 4
10.3. metabolic processes (e.g., photosynthesis, respiration)	0 1 2 3 4
10.4. ecological interrelationship (e.g., energy flow, bio-geochemical cycles)	0 1 2 3 4
10.5. characteristics of chemical bonds	0 1 2 3 4
10.6. types and rates of chemical reactions	0 1 2 3 4
10.7. mechanics (e.g., motion, gravity, force)	0 1 2 3 4
10.8. characteristics of waves (e.g., light, sound, water, seismic)	0 1 2 3 4

1. Evaluate the importance of each *italicized* knowledge statement for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers.

2. Evaluate the importance of each knowledge element in the context of its respective *italicized* knowledge statement.

CIRCLE THE NUMBER THAT BEST DESCRIBES YOUR JUDGMENT FOR EACH STATEMENT AND ELEMENT

0	1	2	3	4
Of no importance	Of little importance	Moderately important	Important	Very important

I. BASIC SCIENTIFIC PRINCIPLES (cont.)		IMPORTANCE
E. Matter and Energy		
11.	*Understand the patterns, inter- and intrarelationships of matter and energy*	0 1 2 3 4
11.1.	physical/chemical properties (e.g., states, reactivity, specific gravity, porosity)	0 1 2 3 4
11.2.	particulate nature of matter (e.g., atoms, ions, isotopes, molecules)	0 1 2 3 4
11.3.	organization of matter (e.g., elements, compounds, substances, mixtures, solutions, colloids)	0 1 2 3 4
11.4.	physical vs. chemical change	0 1 2 3 4
11.5.	forms of energy/energy transformations (e.g., kinetic, potential, thermal, electrical)	0 1 2 3 4
11.6.	conservation of mass/energy	0 1 2 3 4
11.7.	force (e.g., gravitational, pressure, mass vs. weight, buoyancy, friction)	0 1 2 3 4
12.	*Understand issues associated with the use and production of various energy sources (e.g., fossil fuels, nuclear, hydroelectric, geothermal)*	0 1 2 3 4
12.1.	renewable vs. nonrenewable sources	0 1 2 3 4
12.2.	tradeoffs associated with various sources	0 1 2 3 4
12.3.	conservation	0 1 2 3 4
F. Heat and Thermodynamics		
13.	*Understand the transfer and measurement of heat and the laws of thermodynamics*	0 1 2 3 4
13.1.	temperature scales and measurement	0 1 2 3 4
13.2.	temperature vs. heat	0 1 2 3 4
13.3.	heat transfer mechanisms (conduction, convection, radiation)	0 1 2 3 4
13.4.	heat sources (e.g., radioactive decay, friction)	0 1 2 3 4
13.5.	thermal expansion and contraction	0 1 2 3 4
13.6.	laws of thermodynamics	0 1 2 3 4
13.7.	heat capacity and specific heat	0 1 2 3 4
13.8.	phase changes	0 1 2 3 4
13.9.	kinetic molecular theory	0 1 2 3 4
13.10.	temperature, pressure, volume relationships	0 1 2 3 4
G. Atomic and Nuclear Structure		
14.	*Understand the structure of atoms*	0 1 2 3 4
14.1.	historical development of atomic models	0 1 2 3 4
14.2.	structure of the atom including subatomic particles (e.g., electrons, protons, neutrons, neutrinos)	0 1 2 3 4

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I. **BASIC SCIENTIFIC PRINCIPLES (cont.)** — **IMPORTANCE**

Understand the structure of atoms (cont.)

14.3. atomic mass, atomic number, mass number, isotopes, and ions 0 1 2 3 4

14.4. physical and chemical properties related to electron configuration (e.g., atomic valence, reactivity, periodic trends) 0 1 2 3 4

15. *Understand nuclear reactions* 0 1 2 3 4

15.1. nuclear forces and binding energy 0 1 2 3 4

15.2. characteristic properties and effects of radiation 0 1 2 3 4

15.3. artificial and natural radiation 0 1 2 3 4

15.4. half-life of radioactive isotopes 0 1 2 3 4

15.5. nuclear reactions (e.g., transmutation, fission, fusion) 0 1 2 3 4

16. **Overall evaluation of the importance of Basic Scientific Principles** 0 1 2 3 4

17. How well do the statements in section I cover the important aspects of Basic Scientific Principles?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

_____

_____

II. **TECTONICS**

A. Plate Tectonics: The Unifying Theory

18. *Understand the unifying theory of plate tectonics* 0 1 2 3 4

18.1. sources of evidence (e.g., seismic, magnetic, fossil) 0 1 2 3 4

18.2. plate boundaries: convergent, divergent, transform 0 1 2 3 4

18.3. mantle convection 0 1 2 3 4

18.4. topography of the sea floor 0 1 2 3 4

18.5. hot spots 0 1 2 3 4

18.6. location on the Earth of geographical features that have tectonic significance (e.g., oceans, mountain chains, islands, rift valleys) 0 1 2 3 4

18.7. distribution and types of earthquakes and volcanoes (e.g., "Ring of Fire") 0 1 2 3 4

B. Mountain-forming Processes

19. *Understand the processes by which the crust is deformed* 0 1 2 3 4

19.1. compression and extension of the crust 0 1 2 3 4

19.2. geologic structures (e.g., folds, faults, joints) 0 1 2 3 4

19.3. igneous and metamorphic processes 0 1 2 3 4

19.4. isostatic adjustment 0 1 2 3 4

1. **Evaluate the importance of each *italicized* knowledge statement for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers.**

2. **Evaluate the importance of each knowledge element in the context of its respective *italicized* knowledge statement.**

CIRCLE THE NUMBER THAT BEST DESCRIBES YOUR JUDGMENT FOR EACH STATEMENT AND ELEMENT

0	1	2	3	4
Of no importance	Of little importance	Moderately important	Important	Very important

II. TECTONICS (cont.)	IMPORTANCE
C. The Earth's Interior	
20. *Understand how earthquakes occur and provide information about the Earth's interior*	0 1 2 3 4
20.1. earthquake, magnitude, and intensity	0 1 2 3 4
20.2. seismograms and seismic waves	0 1 2 3 4
20.3. internal structure of the Earth	0 1 2 3 4
20.4. composition of the Earth	0 1 2 3 4
20.5. heat sources within the Earth	0 1 2 3 4
20.6. location of resources and plate boundaries	0 1 2 3 4
21. *Understand the origin and effects of the Earth's magnetic field*	0 1 2 3 4
21.1. possible causes (e.g., dynamo theory)	0 1 2 3 4
21.2. rock magnetism	0 1 2 3 4
21.3. geomagnetic reversals	0 1 2 3 4
21.4. Van Allen belts	0 1 2 3 4
21.5. auroras	0 1 2 3 4
22. **Overall evaluation of the importance of Tectonics**	0 1 2 3 4

23. How well do the statements in section II cover the important aspects of Tectonics?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

III. THE ROCK CYCLE

IMPORTANCE

A. Earth Materials

24. *Understand the characteristics of minerals and the methods used to identify them* 0 1 2 3 4

24.1. definition 0 1 2 3 4

24.2. crystal structure 0 1 2 3 4

24.3. relationship between structure and physical properties (e.g., hardness, cleavage, specific gravity) 0 1 2 3 4

24.4. mineral classes (e.g., silicates, carbonates, elements) 0 1 2 3 4

25. *Understand the cycling of Earth materials* 0 1 2 3 4

26. *Understand the processes by which rocks are formed by crystallization* 0 1 2 3 4

26.1. formation of and crystallization from a magma 0 1 2 3 4

26.2. metamorphic processes 0 1 2 3 4

26.3. characteristics of igneous and metamorphic rocks 0 1 2 3 4

26.4. evidence for composition of the Earth's interior 0 1 2 3 4

B. Weathering

27. *Understand the processes of weathering and soil formation* 0 1 2 3 4

27.1. physical processes 0 1 2 3 4

27.2. chemical processes 0 1 2 3 4

27.3. soil profiles 0 1 2 3 4

27.4. types of soil 0 1 2 3 4

C. Sedimentation

28. *Understand sedimentary processes and how rocks are formed from these processes* 0 1 2 3 4

28.1. erosion, transportation, and deposition by water, wind, and ice 0 1 2 3 4

28.2. sedimentary structures (e.g., bedding, ripples) 0 1 2 3 4

28.3. post-depositional processes (e.g., burial, lithification, cementation) 0 1 2 3 4

D. Earth Resources

29. *Analyze the interrelationships between civilization and Earth materials as resources* 0 1 2 3 4

29.1. fuel resources (e.g., coal, petroleum, uranium) 0 1 2 3 4

29.2. mineral resources (e.g., aluminum, iron, gold) 0 1 2 3 4

29.3. sediments as resources (e.g., sand, gravel, limestone placers) 0 1 2 3 4

29.4. geographic distribution of resources vs. population patterns 0 1 2 3 4

29.5. issues related to the extraction and reclamation of resources 0 1 2 3 4

E. Landscapes

30. *Understand the processes by which a landscape evolves* 0 1 2 3 4

30.1. mass wasting (e.g., landslides, avalanches) 0 1 2 3 4

30.2. running water 0 1 2 3 4

30.3. groundwater (e.g., karst topography, permafrost) 0 1 2 3 4

1. **Evaluate the importance of each *italicized* knowledge statement for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers.**

2. **Evaluate the importance of each knowledge element in the context of its respective *italicized* knowledge statement.**

CIRCLE THE NUMBER THAT BEST DESCRIBES YOUR JUDGMENT FOR EACH STATEMENT AND ELEMENT

0	1	2	3	4
Of no importance	**Of little importance**	**Moderately important**	**Important**	**Very Important**

III. THE ROCK CYCLE (cont.) **IMPORTANCE**

Understand the processes by which a landscape evolves (cont.)

30.4. waves and currents (e.g., beaches, sea caves) 0 1 2 3 4

30.5. glaciers 0 1 2 3 4

30.6. wind 0 1 2 3 4

30.7. sedimentary processes in various geomorphic environments (e.g., marine, desert, arctic) 0 1 2 3 4

31. *Recognize and interpret geologic features as represented by photographs, topographic and geologic maps* 0 1 2 3 4

32. *Analyze the interrelationships between civilization and internal and external processes that shape the land* 0 1 2 3 4

32.1. natural hazards (e.g., landslides, floods, earthquakes, volcanic action) 0 1 2 3 4

32.2. civilization's influence on weathering and erosion (e.g., acid rain, road building, mining practices 0 1 2 3 4

32.3. civilizations influence on soils (e.g., urbanization, irrigation, soil conservation) . . 0 1 2 3 4

33. **Overall evaluation of the importance of The Rock Cycle** 0 1 2 3 4

34. How well do the statements in section III cover the important aspects of The Rock Cycle?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

_____

_____

IV. HISTORY OF THE EARTH

A. The Record in the Rocks

35. *Understand the basic assumptions of stratigraphic correlation* 0 1 2 3 4

35.1. basic principles (e.g., original horizontality, superposition, cross-cutting relationships) 0 1 2 3 4

35.2. interpretation of sequence of events from a map and/or profile 0 1 2 3 4

36. *Understand how rocks provide a record of the history of the Earth* 0 1 2 3 4

36.1. early history of the Earth 0 1 2 3 4

36.2. ancient continents including Gondwanaland and Pangea 0 1 2 3 4

36.3. the evolution of North America (e.g., mountain-building, accretion, basin formation) 0 1 2 3 4

36.4. methods of fossilizatien 0 1 2 3 4

36.5. the development of life 0 1 2 3 4

36.6. mass extinctions 0 1 2 3 4

36.7. paleoenvironments and paleoclimates 0 1 2 3 4

B. Time and How It Is Measured

37. *Understand how time is measured* 0 1 2 3 4

37.1. relative vs. absolute time 0 1 2 3 4

37.2. methods used to measure absolute time (e.g., radioactive isotopes) 0 1 2 3 4

37.3. methods used to measure relative time (e.g., superposition, fossils) 0 1 2 3 4

37.4. the geologic time scale 0 1 2 3 4

38. **Overall evaluation of the importance of History of the Earth and Its Inhabitants** 0 1 2 3 4

39. How well do the statements in section IV cover the important aspects of History of the Earth and Its Inhabitants?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

_____

_____

1. **Evaluate the importance of each *italicized* knowledge statement for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers.**

2. **Evaluate the importance of each knowledge element in the context of its respective *italicized* knowledge statement.**

CIRCLE THE NUMBER THAT BEST DESCRIBES YOUR JUDGMENT FOR EACH STATEMENT AND ELEMENT

0	1	2	3	4
Of no importance	Of little importance	Moderately important	Important	Very Important

V. THE WATER CYCLE

IMPORTANCE

A. Unique Properties of Water

40. *Understand the structure of the water molecule as it relates to its special properties (e.g., high specific heat, polarity, density changes)* 0 1 2 3 4

B. The Hydrologic Cycle

41. *Understand the paths that water follows as it moves through the water cycle and the energy transfers that accompany this movement* 0 1 2 3 4

41.1. phase changes (e.g., evaporation, condensation and precipitation) 0 1 2 3 4

41.2. surface processes (e.g., runoff, infiltration, transpiration) 0 1 2 3 4

41.3. alteration of the cycle by human activities (e.g., deforestation, urban development) 0 1 2 3 4

C. Weather and Climate

42. *Understand the systematic development and movement of weather patterns and phenomena* 0 1 2 3 4

42.1. evolution of the atmosphere 0 1 2 3 4

42.2. structure and composition of the atmosphere 0 1 2 3 4

42.3. temperature: seasonal variations, heat budget, albedo, latitude, elevation 0 1 2 3 4

42.4. water in the air: specific and relative humidity, dewpoint (frost-point) 0 1 2 3 4

42.5. atmospheric circulation (e.g., Coriolis effect, global and local winds, high and low pressure systems) 0 1 2 3 4

42.6. fronts, storms, and severe weather events 0 1 2 3 4

42.7. types of clouds and precipitation 0 1 2 3 4

42.8. weather map analysis 0 1 2 3 4

42.9. interpretation of atmospheric data 0 1 2 3 4

42.10. interactions of the ocean and the atmosphere (e.g., el Niño, carbon dioxide cycle 0 1 2 3 4

43. *Analyze the natural factors contributing to climate* 0 1 2 3 4

43.1. global circulation of the atmosphere and the oceans 0 1 2 3 4

43.2. climatic zones caused by latitude, altitude and topography, bodies of water, and prevailing winds 0 1 2 3 4

43.3. long- and short-term climate change 0 1 2 3 4

43.4. variations in solar output 0 1 2 3 4

43.5. volcanic eruptions and meteorite impact 0 1 2 3 4

43.6. changes due to tectonic environment (e.g., ice ages, rain, shadow deserts) 0 1 2 3 4

V. THE WATER CYCLE (cont.)		IMPORTANCE
44.	*Understand the interrelationships between civilization and weather and climate*	0 1 2 3 4
44.1.	air pollution: gases, particulates, secondary air pollution	0 1 2 3 4
44.2.	acid precipitation (e.g., rain, snow, fog)	0 1 2 3 4
44.3.	urban climates (e.g., heat islands, smog)	0 1 2 3 4
44.4.	ozone as a pollutant	0 1 2 3 4
44.5.	changes to the protective ozone layer	0 1 2 3 4
44.6.	effects of greenhouse gases	0 1 2 3 4
44.7.	pollution control (benefits, methods, costs, regulations)	0 1 2 3 4
44.8.	power generated by wind	0 1 2 3 4
44.9.	weather modification (e.g., cloud seeding, hail suppression)	0 1 2 3 4
D. Waters of the Land		
45.	*Understand the processes by which water moves on and beneath the Earth's surface*	0 1 2 3 4
45.1.	runoff and infiltration	0 1 2 3 4
45.2.	rivers: discharge, current, load, grades, intermittent streams	0 1 2 3 4
45.3.	floods	0 1 2 3 4
45.4.	lakes and playas	0 1 2 3 4
45.5.	groundwater and water table	0 1 2 3 4
45.6.	aquifers	0 1 2 3 4
45.7.	porosity and permeability	0 1 2 3 4
45.8.	artesian/non-artesian wells	0 1 2 3 4
45.9.	springs	0 1 2 3 4
45.10.	geysers and hot springs	0 1 2 3 4
46.	*Analyze the interrelationships between civilization and water resources*	0 1 2 3 4
46.1.	management and conservation of water as a resource	0 1 2 3 4
46.2.	water pollution	0 1 2 3 4
46.3.	sewage and wastewater treatment	0 1 2 3 4
46.4.	wells and effects of groundwater depletion	0 1 2 3 4
46.5.	effects of urbanization	0 1 2 3 4
46.6.	hydro(electric) power	0 1 2 3 4
46.7.	aquifers and surface reservoirs	0 1 2 3 4
46.8.	land development near rivers, lakes, and floodplains	0 1 2 3 4
46.9.	recreational use and aesthetic considerations	0 1 2 3 4
E. Water in the Ocean		
47.	*Understand the physical and chemical characteristics and processes of the oceans*	0 1 2 3 4
47.1.	origin and evolution of the oceans	0 1 2 3 4
47.2.	geographic locations of major oceans and seas	0 1 2 3 4
47.3.	variations in salinity, temperature, and density	0 1 2 3 4
47.4.	chemical cycles (dissolved ions)	0 1 2 3 4
47.5.	nutrient cycles and upwellings	0 1 2 3 4

1. **Evaluate the importance of each *italicized* knowledge statement for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers.**

2. **Evaluate the importance of each knowledge element in the context of its respective *italicized* knowledge statement.**

CIRCLE THE NUMBER THAT BEST DESCRIBES YOUR JUDGMENT FOR EACH STATEMENT AND ELEMENT

0	1	2	3	4
Of no importance	Of little importance	Moderately important	Important	Very important

V. THE WATER CYCLE (cont.) — **IMPORTANCE**

Understand the physical and chemical characteristics and processes of the oceans (cont.)

47.6.	oceanic circulation patterns	0 1 2 3 4
47.7.	tides, waves, and currents	0 1 2 3 4
47.8.	nearshore waters including estuaries	0 1 2 3 4
47.9.	energy and matter exchange with atmosphere	0 1 2 3 4
48.	*Understand and analyze the interrelationships between the waters of the oceans and the solid Earth*	0 1 2 3 4
48.1.	maps and profiles of the oceans, bays, estuaries, and shorelines	0 1 2 3 4
48.2.	erosional and depositional processes	0 1 2 3 4
48.3.	sedimentation: chemical and mechanical	0 1 2 3 4
48.4.	reefs and atolls	0 1 2 3 4
48.5.	hydrothermal convection at mid-ocean ridges	0 1 2 3 4
48.6.	importance of ocean water at plate boundaries	0 1 2 3 4
49.	*Analyze the interrelationships between civilization and the oceans*	0 1 2 3 4
49.1.	ocean pollution	0 1 2 3 4
49.2.	beach erosion and shoreline stabilization	0 1 2 3 4
49.3.	coastal and offshore development issues	0 1 2 3 4
49.4.	energy from the sea: tides, waves, currents, upwellings	0 1 2 3 4
49.5.	management of resources from the ocean	0 1 2 3 4
49.6.	causes and effects of sea-level changes	0 1 2 3 4

F. Ice

50.	*Understand the processes that form and transform ice on the Earth*	0 1 2 3 4
50.1.	glaciers, ice caps, and permafrost	0 1 2 3 4
50.2.	formation and movement of bodies of ice	0 1 2 3 4
50.3.	changes in climate, sea level, and history of ice advances and retreats	0 1 2 3 4
50.4.	erosional and depositional processes	0 1 2 3 4
51.	*Understand the interrelationships between civilizations and the cryospheres (ice)*	0 1 2 3 4
51.1.	development on permafrost (e.g., Alaskan pipeline)	0 1 2 3 4
51.2.	land bridges	0 1 2 3 4
51.3.	hazards of ice (e.g., icebergs)	0 1 2 3 4
51.4.	ice as a resource	0 1 2 3 4

V. THE WATER CYCLE (cont.)

IMPORTANCE

52. **Overall evaluation of the importance of The Water Cycle** 0 1 2 3 4

53. How well do the statements in section V cover the important aspects of The Water Cycle?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

_____

_____

VI. THE EARTH IN SPACE

A. Earth-Moon-Sun

54. *Understand the consequences of the Earth's characteristics and motions* 0 1 2 3 4

54.1. shape and size (e.g., latitude, longitude) 0 1 2 3 4

54.2. rotation (e.g., length of day, time zones) 0 1 2 3 4

54.3. revolution (e.g., length of year) 0 1 2 3 4

54.4. tilt (e.g., seasons) 0 1 2 3 4

54.5. albedo, heat budget 0 1 2 3 4

55. *Analyze the relationships between the Earth, Moon, and Sun* 0 1 2 3 4

55.1. phases of the Moon 0 1 2 3 4

55.2. tides 0 1 2 3 4

55.3. eclipses 0 1 2 3 4

B. Solar System

56. *Characterize and relate the components of the solar system in terms of composition, size, motions, and history* 0 1 2 3 4

56.1. origin of the solar system 0 1 2 3 4

56.2. the Sun: structure, composition, and features 0 1 2 3 4

56.3. laws of planetary motion 0 1 2 3 4

56.4. planets and natural satellites 0 1 2 3 4

56.5. surface and history of nearby bodies (e.g., Moon, Mars, Venus) 0 1 2 3 4

56.6. meteoroids, asteroids, and comets 0 1 2 3 4

56.7. ancient astronomy 0 1 2 3 4

1. **Evaluate the importance of each *italicized* knowledge statement for the competent job performance of all beginning (newly licensed/certified) Earth and Space Science teachers.**

2. **Evaluate the importance of each knowledge element in the context of its respective *italicized* knowledge statement.**

CIRCLE THE NUMBER THAT BEST DESCRIBES YOUR JUDGMENT FOR EACH STATEMENT AND ELEMENT

0	1	2	3	4
Of no importance	Of little importance	Moderately important	Important	Very Important

VI. THE EARTH IN SPACE (cont.) — IMPORTANCE

C. Stars

57. *Understand the characteristics of stars and the processes that occur within them* . . 0 1 2 3 4

57.1. properties of stars (e.g., mass, spectral class, magnitude) 0 1 2 3 4

57.2. relative distances and velocities (e.g., parallax, Doppler shift) 0 1 2 3 4

57.3. stages in the life cycles of stars (e.g., nebula, main sequence, giants, dwarfs, black holes) 0 1 2 3 4

57.4. H-R diagram 0 1 2 3 4

58. *Understand the interrelationships between civilization and astronomical objects* . . . 0 1 2 3 4

58.1. constellations and star charts 0 1 2 3 4

58.2. space exploration 0 1 2 3 4

58.3. planetariums 0 1 2 3 4

D. Galaxies and the Universe

59. *Understand the structure of the Milky Way and other galaxies* 0 1 2 3 4

59.1. multiple star systems (e.g., binaries, clusters) 0 1 2 3 4

59.2. characteristics of galaxies 0 1 2 3 4

59.3. relative distances and motions of objects in the universe 0 1 2 3 4

59.4. quasars 0 1 2 3 4

59.5. structure of the universe (e.g., curvature, gravitational/time relationship) 0 1 2 3 4

59.6. hypotheses of the origin and evolution of the universe 0 1 2 3 4

60. **Overall evaluation of the importance of The Earth in Space** 0 1 2 3 4

61. How well do the statements in section VI cover the important aspects of The Earth in Space?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

PART II - RECOMMENDATIONS FOR TEST CONTENT

Listed below are six broad topics that may be covered on the new licensing examination for Earth and Space Science. If the examination contained 100 questions, how many questions should be included from each topic? If you feel a category should not be included in the exam, put 0 in the space provided. Make sure your responses sum to 100.

TOPICS	NUMBER OF TEST QUESTIONS (out of 100)
62. BASIC SCIENTIFIC PRINCIPLES	_____
63. TECTONICS	_____
64. THE ROCK CYCLE	_____
65. HISTORY OF THE EARTH	_____
66. THE WATER CYCLE	_____
67. THE EARTH IN SPACE	_____
TOTAL	100

PART III - BACKGROUND INFORMATION

The information that you provide in this section is completely confidential and will be used for research purposes only. Please answer the questions by circling the number that most closely describes you or your professional activities. Unless otherwise indicated, please circle only one response for each question.

68. Where do you work?

1. Alabama
2. Alaska
3. Arizona
4. Arkansas
5. California
6. Colorado
7. Connecticut
8. Delaware
9. District of Columbia
10. Florida
11. Georgia
12. Hawaii
13. Idaho
14. Illinois
15. Indiana
16. Iowa
17. Kansas
18. Kentucky
19. Louisiana
20. Maine
21. Maryland
22. Massachusetts
23. Michigan
24. Minnesota
25. Mississippi
26. Missouri
27. Montana
28. Nebraska
29. Nevada
30. New Hampshire
31. New Jersey
32. New Mexico
33. New York
34. North Carolina
35. North Dakota
36. Ohio
37. Oklahoma
38. Oregon
39. Pennsylvania
40. Rhode Island
41. South Carolina
42. South Dakota
43. Tennessee
44. Texas
45. Utah
46. Vermont
47. Virginia
48. Washington
49. West Virginia
50. Wisconsin
51. Wyoming

69. What is your age?

1. Under 25
2. 25-34
3. 35-44
4. 45-54
5. 55-64
6. Over 64

70. What is your sex?

1. Female
2. Male

71. Which of the following best describes the area in which you work?

1. Urban
2. Suburban
3. Rural

* Earth Science may also be referred to as Earth and Space Science or Geoscience and includes Astronomy, Geology, Meteorology, and Oceanography.

72. How do you describe yourself?

1. Native American, American Indian, or Alaskan Native
2. Asian American, Asian, Native Hawaiian, or Pacific Islander
3. African American or Black
4. Mexican American or Chicano
5. Puerto Rican
6. Latin American, South American, Central American, or other Hispanic
7. White
8. Other (please specify)_____

73. Which of the following best describes your current employment status?

1. Teacher
2. Principal or assistant principal
3. School-level administrator
4. District-level administrator
5. State-level administrator
6. College faculty
7. Other (please specify)_____

74. Which of the following best describes your highest academic attainment?

1. Less than a bachelor's
2. Bachelor's
3. Bachelor's + additional credits
4. Master's
5. Master's + additional credits
6. Doctorate

75. In which of the following subject areas is your highest academic degree?

1. Earth Science
2. Life Science/Biology
3. Physical Science
4. Mathematics
5. Administration
6. Mathematics and/or Science Education
7. Other (please specify)_____

76. What do you consider to be your content area of expertise within Earth Science?

1. Astronomy
2. Geology
3. Meteorology
4. Oceanography
5. Other (please specify)_____

* Earth Science may also be referred to as Earth and Space Science or Geoscience and includes Astronomy, Geology, Meteorology, and Oceanography.

77. How many college- or graduate-level courses in Earth Science have you completed?

1. 0
2. 1 - 3
3. 4 - 6
4. 7 - 9
5. 10 or more

78. Are you certified to teach Earth Science?

1. Yes (respond to question #79)
2. No (proceed to question #80)

79. What is the title of your certification or endorsement?

1. Comprehensive Science (7 - 12) or (9 - 12)
2. Earth Science
3. General Science
4. Other (please specify)_____

80. How many years have you taught Earth Science?

1. Never taught Earth Science
2. Less than a year
3. 1 - 3 years
4. 4 - 6 years
5. 7 - 10 years
6. 11 - 15 years
7. 16 or more years

81. At what grade-levels have you <u>taught</u> Earth Science? (Circle all that apply)

1. Never taught Earth Science
2. 6
3. 7
4. 8
5. 9
6. 10
7. 11
8. 12
9. college

* Earth Science may also be referred to as Earth and Space Science or Geoscience and includes Astronomy, Geology, Meteorology, and Oceanography.

82. At what grade-levels are you currently teaching Earth Science? (Circle all that apply)

1. Currently do not teach Earth Science
2. 6
3. 7
4. 8
5. 9
6. 10
7. 11
8. 12
9. college

83. What is the name of the Earth Science course(s) you are currently teaching? (Circle all that apply)

1. Currently do not teach Earth Science
2. Earth Science
3. General Science
4. Astronomy
5. Environmental Science
6. Geology
7. Meteorology
8. Oceanography
9. Other (please specify)_____

84. Which of the following describes your current teaching assignment? (Circle all that apply)

1. Do not teach
2. Life Science/Biology
3. Earth Science
4. Ecology
5. General Science
6. Marine Science
7. Physical Science
8. Physics
9. Chemistry
10. Science Education
11. Other (please specify)_____

* Earth Science may also be referred to as Earth and Space Science or Geoscience and includes Astronomy, Geology, Meteorology, and Oceanography.

85. To which of the following organizations do you belong? (Circle all that apply)

1. American Association of Physics Teachers
2. American Association for the Advancement of Science
3. American Astronomical Society
4. American Chemical Society
5. American Federation of Teachers
6. American Meteorological Society
7. Association of Astronomy Educators
8. National Association of Biology Teachers
9. National Association of Geology Teachers
10. National Association for Research in Science Teaching
11. National Earth Science Teachers Association
12. National Marine Educators Association
13. National Science Supervisors Association
14. National Science Teachers Association
15. National Association for Science, Technology, and Society
16. National Education Association
17. Other (please specify)_____

THANK YOU FOR COMPLETING THIS INVENTORY.
PLEASE RETURN IT WITHIN <u>10 DAYS</u> USING THE ENCLOSED ENVELOPE.

* Earth Science may also be referred to as Earth and Space Science or Geoscience and includes Astronomy, Geology, Meteorology, and Oceanography.

Appendix E

Survey Cover Letter

May 20, 1993

Dear Colleague:

Educational Testing Service (ETS) is asking you, as an active Earth and Space Science professional, to participate in the development of a new licensure/certification assessment for Earth and Space Science teachers. ETS is developing a new series of teacher licensure/certification tests, The Praxis Series: Professional Assessments for Beginning Teachers™. These assessments include a set of Subject Assessments which measure subject matter knowledge and, where appropriate, knowledge about teaching that subject. One of these Subject Assessments is being developed for teacher candidates seeking licensure/certification specifically in Earth and Space Science. I am asking for your help as we develop the Subject Assessment in Earth and Space Science.

As part of the developmental process of the Subject Assessment in Earth and Space Science, ETS has worked closely with teachers, college faculty, and school administrators to identify potentially important knowledge areas. The enclosed inventory has been developed as a way to obtain your judgments of the importance of these knowledge areas for beginning (newly licensed/certified) Earth and Space Science teachers. The information obtained from these inventories will be used to guide the design and content of the Subject Assessment in Earth and Space Science.

This inventory is being mailed to approximately 1,000 professionals in the specialty area of Earth and Space Science. Its value is directly related to the number of individuals who return their inventories. Because you represent a large number of professionals, your judgments are very important. Your responses will be kept in strict confidence. The inventory asks for some background information about you; this is solely for purposes of describing the group of respondents. A field test with Earth and Space Science teachers indicated that, on average, only 60 minutes were required to complete the inventory.

The results of this study are expected to be widely disseminated and should be very useful to the profession. A postage-paid envelope is enclosed for the return of your completed inventory. Thank you for your participation in this very important project.

Sincerely,

Richard Tannenbaum, Ph.D.
Research Scientist

Enclosures

Appendix F

Respondent Demographics

	Number	Percent
GEOGRAPHIC REGION		
Northeast	89	29.2
Central	82	26.9
Southern	63	20.7
Far West	71	23.3
Total	305	
AGE (years)		
Under 25	1	0.3
25 - 34	38	12.5
35 - 44	100	32.9
45 - 54	122	40.1
55 - 64	34	11.2
Over 64	9	3.0
Total	304	
SEX		
Female	82	27.0
Male	222	73.0
Total	304	
SCHOOL SETTING		
Urban	95	31.9
Suburban	102	34.2
Rural	101	33.9
Total	298	
RACE/ETHNICITY		
Native American, American Indian, or Alaskan Native	6	2.0
Asian American, Asian, Native Hawaiian, or Pacific Islander	6	2.0
African American or Black	6	2.0
Mexican American or Chicano	2	0.7
Puerto Rican	0	0.0

	Number	Percent
Latin American, South America, Central American, or other Hispanic	4	1.3
White	264	88.3
Other	11	3.7
Total	299	
CURRENT EMPLOYMENT STATUS		
Teacher	181	60.9
Principal or assistant principal	1	0.3
School-level administrator	1	0.3
District-level administrator	0	0.0
State-level administrator	19	6.4
College faculty	84	28.3
Other	11	3.7
Total	297	
HIGHEST EDUCATIONAL ATTAINMENT		
Less than Bachelor's	0	0.0
Bachelor's	2	0.7
Bachelor's + Credits	50	16.5
Master's	28	9.2
Master's + Credits	132	43.6
Doctorate	91	30.0
Total	303	
SUBJECT AREA		
Earth Science	121	43.1
Life Science/Biology	55	19.6
Physical Science	16	5.7
Mathematics	5	1.8
Administration	15	5.3
Mathematics and/or Science Education	23	8.2
Other	46	16.4
Total	281	

	Number	Percent
AREA OF EXPERTISE		
Astronomy	29	11.3
Geology	168	65.4
Meteorology	17	6.6
Oceanography	16	6.2
Other	27	10.5
Total	257	
EARTH SCIENCE COURSES COMPLETED		
0	19	6.4
1-3	39	13.1
4-6	32	10.8
7-9	26	8.8
10 or more	180	60.6
Total	297	
CERTIFIED IN EARTH SCIENCE		
Yes	182	61.9
No	112	38.1
Total	294	
CERTIFICATION TITLE		
Comprehensive Science	49	29.2
Earth Science	62	36.9
General Science	27	16.1
Other	30	17.9
Total	168	
TEACHING EXPERIENCE (years)		
Never taught	11	3.7
Less than 1	5	1.7
1 - 3	34	11.5
4 - 6	46	15.5

	Number	Percent
7 - 10	44	14.9
11 - 15	43	14.5
16 or more	113	38.2
Total	296	
GRADE LEVELS TAUGHT [1]		
Never taught Earth Science	10	1.6
6	9	1.4
7	29	4.6
8	65	10.3
9	153	24.2
10	75	11.9
11	92	14.6
12	88	13.9
College	111	17.6
Total	632	100.0
GRADES CURRENTLY TEACHING [1]		
Currently do not teach Earth Science	39	8.2
6	2	0.4
7	9	1.9
8	23	4.8
9	118	24.7
10	57	11.9
11	69	14.5
12	69	14.5
College	91	19.1
Total	477	100.0
COURSES CURRENTLY TEACHING [1]		
Currently do not teach Earth Science	29	6.5
Earth Science	164	36.9

[1] **Multiple responses are permitted.**

	Number	Percent
General Science	14	3.1
Astronomy	24	5.4
Environmental Science	29	6.5
Geology	75	16.8
Meteorology	17	3.8
Oceanography	35	7.9
Other	58	13.0
Total	445	100.0
CURRENT TEACHING ASSIGNMENT [1]		
Do not teach	18	3.4
Life Science/Biology	62	11.9
Earth Science	237	45.3
Ecology	9	1.7
General Science	21	4.0
Marine Science	17	3.3
Physical Science	39	7.5
Physics	23	4.4
Chemistry	29	5.5
Science Education	8	1.5
Other	60	11.5
Total	523	100.0
MEMBERSHIP IN ORGANIZATIONS [1]		
American Association of Physics Teachers	5	0.9
American Association for the Advancement of Science	30	5.7
American Astronomical Society	3	0.6
American Chemical Society	12	2.3
American Federation of Teachers	18	3.4
American Meteorological Society	6	1.1
Association of Astronomy Educators	4	0.8
National Association of Biology Teachers	16	3.0

[1] **Multiple responses are permitted.**

	Number	Percent
National Association of Geology Teachers	39	7.4
National Association for Research in Science Teaching	5	0.9
National Earth Science Teachers Association	37	7.0
National Marine Educators Association	5	0.9
National Science Supervisors Association	14	2.7
National Science Teachers Association	106	20.1
National Association for Science, Technology, and Society	1	0.2
National Education Association	100	19.0
Other	126	23.9
Total	527	100.0

Appendix G

Mean Importance Ratings: Teachers and Teacher Educators

	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
I. BASIC SCIENTIFIC PRINCIPLES				
A. Scientific Methodology and Philosophy				
1. *Understand the methods of scientific problem solving*	3.71	0.57	3.76	0.65
1.1. facts, models, theories, hypotheses, and laws	3.37	0.72	3.45	0.79
1.2. process skills (e.g., problem identification, observation, measurement, inference, classification)	3.65	0.58	3.52	0.80
1.3. investigative and experimental methods	3.48	0.67	3.21	0.93
2. *Understand the importance of the study of Earth and Space Science*	3.68	0.52	3.55	0.65
2.1. the significance of Earth and Space Science in everyday life (e.g., social/environmental issues, aesthetics, recreation)	3.51	0.66	3.35	0.74
2.2. integration of Earth and Space Science in other science fields	3.22	0.69	3.19	0.76
2.3. the interrelatedness of Earth and Space Science and other fields of study (e.g., history, literature, art)	2.85	0.85	2.57	0.95
2.4. careers in Earth and Space Sciences and related fields	2.92	0.81	2.69	0.79
3. *Demonstrate knowledge of historical roots of science and the contributions made by major historical figures as well as members of cultural/ethnic groups (e.g., ancient Chinese and Greek astronomers, Galileo, Darwin, Curie, Hutton)*	2.51	0.80	2.59	0.84
B. Mathematics, Measurement, and Data Manipulation				
4. *Understand the use of various measurement systems*	3.49	0.66	3.56	0.57
4.1. English system	2.84	1.04	2.87	1.12
4.2. metric (SI) system	3.58	0.67	3.77	0.48
4.3. exponential notation	2.79	0.97	3.40	0.76
4.4. map scales	3.38	0.71	3.38	0.78
4.5. significant figures	2.61	0.97	3.16	0.78
4.6. scales specific to Earth and Space Science	3.16	0.81	3.49	0.73
5. *Compile, evaluate, and interpret data, including analysis of errors*	3.27	0.70	3.39	0.73
5.1. compilation and interpretation of data (e.g., text, graphs, charts, tables, photographs, and maps)	3.44	0.67	3.38	0.68
5.2. analysis and evaluation of data	3.31	0.75	3.28	0.77
5.3. national/local databases	2.53	0.84	2.36	0.90
5.4. observational and experimental variation: sources, precision, accuracy, and experimental error	2.80	0.78	3.13	0.75
6. *Understand and interpret maps and photographs*	3.43	0.69	3.30	0.70
6.1. map projections	2.98	0.81	2.69	0.69
6.2. legends, symbols, and scales	3.34	0.73	3.08	0.86
6.3. aerial and satellite photographs	2.81	0.78	2.92	0.74

	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
I. BASIC SCIENTIFIC PRINCIPLES (cont.)				
6.4. topographic maps including bathymetric maps	3.20	0.81	3.33	0.66
6.5. geologic maps	3.01	0.77	3.19	0.74
6.6. weather maps	3.35	0.70	2.74	0.83
C. Laboratory/Field Procedures and Safety				
7. *Understand the proper methods involved in using laboratory and field materials and equipment in a safe and appropriate manner*	3.56	0.64	3.35	0.78
7.1. use of chemicals and equipment (e.g., acids, glassware)	3.30	0.80	3.26	0.80
7.2. preparation, storage, and disposal of materials	3.19	0.83	3.14	0.81
7.3. safety procedures for laboratory and field work	3.57	0.68	3.33	0.82
7.4. laboratory and field hazards	3.49	0.69	3.26	0.77
8. *Understand the appropriate use of equipment/instruments for measurement and observation in Earth and Space Science*	3.23	0.63	3.04	0.75
8.1. Earth's interior (e.g., seismographs)	3.05	0.73	2.84	0.74
8.2. surface of the Earth (e.g., maps, satellite images, microscopes)	3.15	0.67	3.01	0.78
8.3. oceans and ocean floor (e.g., submersibles, sonar)	2.75	0.77	2.61	0.82
8.4. Earth's atmosphere (e.g., barometers, anemometers)	3.22	0.63	2.84	0.80
8.5. astronomical objects (e.g., telescopes, spectroscopes)	2.98	0.75	2.54	0.78
9. *Understand computer and related technologies as they apply to investigative activities*	2.93	0.90	3.07	0.76
9.1. spreadsheets	2.44	0.94	2.63	0.77
9.2. generation of graphs, maps, and profiles	2.79	0.92	2.82	0.73
9.3. simulations including videodisc and CD-ROM	2.66	0.94	2.43	0.86
9.4. interactive systems: using the computer to collect/analyze data	2.72	0.88	2.72	0.86
9.5. accessing national databases and on-line services	2.38	0.93	2.41	0.90
D. Biological, Chemical, and Physical Processes				
10. *Understand fundamental biological, chemical, and physical processes as they apply to the study of Earth and Space Science*	3.26	0.74	3.59	0.58
10.1. characteristics of life forms	2.78	0.90	3.12	0.77
10.2. evolutionary processes (e.g., natural selection, mutation)	2.87	0.97	3.26	0.75
10.3. metabolic processes (e.g., photosynthesis, respiration)	2.51	0.92	2.86	0.87
10.4. ecological interrelationship (e.g., energy flow, bio-geochemical cycles)	2.91	0.83	3.15	0.79
10.5. characteristics of chemical bonds	2.70	0.89	2.99	0.79
10.6. types and rates of chemical reactions	2.44	0.89	2.71	0.85

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	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
I. BASIC SCIENTIFIC PRINCIPLES (cont.)				
10.7. mechanics (e.g., motion, gravity, force)	3.00	0.76	3.20	0.65
10.8. characteristics of waves (e.g., light, sound, water, seismic)	3.01	0.78	3.07	0.74
E. Matter and Energy				
11. *Understand the patterns, inter- and intrarelationships of matter and energy*	3.24	0.74	3.37	0.68
11.1. physical/chemical properties (e.g., states, reactivity, specific gravity, porosity)	3.08	0.78	3.20	0.73
11.2. particulate nature of matter (e.g., atoms, ions, isotopes, molecules)	2.97	0.89	3.34	0.76
11.3. organization of matter (e.g., elements, compounds, substances, mixtures, solutions, colloids)	3.01	0.87	3.29	0.78
11.4. physical vs. chemical change	3.10	0.83	3.28	0.74
11.5. forms of energy/energy transformations (e.g., kinetic, potential, thermal, electrical)	2.85	0.87	3.08	0.75
11.6. conservation of mass/energy	2.88	0.83	3.30	0.72
11.7. force (e.g., gravitational, pressure, mass vs. weight, buoyancy, friction)	3.01	0.74	3.31	0.72
12. *Understand issues associated with the use and production of various energy sources (e.g., fossil fuels, nuclear, hydroelectric, geothermal)*	3.43	0.71	3.35	0.74
12.1. renewable vs. nonrenewable sources	3.42	0.73	3.24	0.81
12.2. tradeoffs associated with various sources	3.22	0.86	3.21	0.84
12.3. conservation	3.47	0.72	3.30	0.75
F. Heat and Thermodynamics				
13. *Understand the transfer and measurement of heat and the laws of thermodynamics*	2.96	0.79	3.05	0.72
13.1. temperature scales and measurement	3.09	0.71	3.10	0.81
13.2. temperature vs. heat	2.92	0.80	3.02	0.76
13.3. heat transfer mechanisms (conduction, convection, radiation)	3.17	0.77	3.06	0.77
13.4. heat sources (e.g., radioactive decay, friction)	2.87	0.75	3.07	0.73
13.5. thermal expansion and contraction	2.65	0.86	2.76	0.81
13.6. laws of thermodynamics	2.47	0.85	2.90	0.84
13.7. heat capacity and specific heat	2.56	0.89	2.68	0.90
13.8. phase changes	2.92	0.83	2.94	0.81
13.9. kinetic molecular theory	2.56	0.87	2.38	0.89
13.10. temperature, pressure, volume relationships	2.86	0.93	3.13	0.77

	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
I. BASIC SCIENTIFIC PRINCIPLES (cont.)				
G. Atomic and Nuclear Structure				
14. *Understand the structure of atoms*	3.14	0.87	3.33	0.74
14.1. historical development of atomic models	2.16	0.88	2.26	0.86
14.2. structure of the atom including subatomic particles (e.g., electrons, protons, neutrons, neutrinos)	2.92	0.96	3.15	0.74
14.3. atomic mass, atomic number, mass number, isotopes, and ions	2.98	0.97	3.36	0.71
14.4. physical and chemical properties related to electron configuration (e.g., atomic valence, reactivity, periodic trends)	2.60	0.96	2.87	0.83
15. *Understand nuclear reactions*	2.67	0.84	2.95	0.76
15.1. nuclear forces and binding energy	2.40	0.90	2.63	0.80
15.2. characteristic properties and effects of radiation	2.58	0.82	2.87	0.83
15.3. artificial and natural radiation	2.41	0.82	2.76	0.78
15.4. half-life of radioactive isotopes	2.83	0.81	3.14	0.84
15.5. nuclear reactions (e.g., transmutation, fission, fusion)	2.60	0.82	2.90	0.82
II. TECTONICS				
A. Plate Tectonics: The Unifying Theory				
18. *Understand the unifying theory of plate tectonics*	3.71	0.53	3.82	0.39
18.1. sources of evidence (e.g., seismic, magnetic, fossil)	3.47	0.65	3.57	0.54
18.2. plate boundaries: convergent, divergent, transform	3.57	0.63	3.60	0.62
18.3. mantle convection	3.33	0.74	3.17	0.73
18.4. topography of the sea floor	3.19	0.74	3.26	0.72
18.5. hot spots	3.12	0.76	3.08	0.77
18.6. location on the Earth of geographical features that have tectonic significance	3.53	0.61	3.53	0.64
18.7. distribution and types of earthquakes and volcanoes (e.g., "Ring of Fire")	3.58	0.57	3.44	0.68
B. Mountain-forming Processes				
19. *Understand the processes by which the crust is deformed*	3.47	0.65	3.56	0.60
19.1. compression and extension of the crust	3.28	0.69	3.38	0.61
19.2. geologic structures (e.g., folds, faults, joints)	3.42	0.63	3.44	0.64
19.3. igneous and metamorphic processes	3.37	0.71	3.34	0.71
19.4. isostatic adjustment	2.88	0.81	3.07	0.79

	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
II. TECTONICS (cont.)				
C. The Earth's Interior				
20. *Understand how earthquakes occur and provide information about the Earth's interior*	3.60	0.59	3.46	0.65
20.1. earthquake, magnitude, and intensity	3.48	0.60	3.22	0.76
20.2. seismograms and seismic waves	3.34	0.67	3.17	0.74
20.3. internal structure of the Earth	3.42	0.63	3.36	0.70
20.4. composition of the Earth	3.33	0.67	3.20	0.79
20.5. heat sources within the Earth	3.13	0.73	3.01	0.74
20.6. location of resources and plate boundaries	3.32	0.72	3.13	0.88
21. *Understand the origin and effects of the Earth's magnetic field*	2.80	0.67	2.99	0.82
21.1. possible causes (e.g., dynamo theory)	2.62	0.77	2.69	0.85
21.2. rock magnetism	2.79	0.75	2.88	0.83
21.3. geomagnetic reversals	2.80	0.77	3.05	0.81
21.4. Van Allen belts	2.49	0.90	2.07	0.87
21.5. auroras	2.58	0.83	1.99	0.86
III. THE ROCK CYCLE				
A. Earth Materials				
24. *Understand the characteristics of minerals and the methods used to identify them*	3.42	0.67	3.41	0.78
24.1. definition	3.16	0.76	3.23	0.88
24.2. crystal structure	2.77	0.91	2.88	0.91
24.3. relationship between structure and physical properties (e.g., hardness, cleavage, specific gravity)	3.31	0.71	3.19	0.87
24.4. mineral classes (e.g., silicates, carbonates, elements)	2.85	0.91	2.92	0.95
25. *Understand the cycling of Earth materials*	3.48	0.64	3.54	0.61
26. *Understand the processes by which rocks are formed by crystallization*	3.29	0.67	3.40	0.71
26.1. formation of and crystallization from a magma	3.23	0.70	3.24	0.73
26.2. metamorphic processes	3.25	0.68	3.20	0.72
26.3. characteristics of igneous and metamorphic rocks	3.38	0.65	3.27	0.77
26.4. evidence for composition of the Earth's interior	3.05	0.74	3.03	0.85

	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
III. THE ROCK CYCLE (cont.)				
B. Weathering				
27. *Understand the processes of weathering and soil formation*	3.46	0.64	3.44	0.68
27.1. physical processes	3.37	0.67	3.36	0.72
27.2. chemical processes	3.34	0.69	3.39	0.69
27.3. soil profiles	2.97	0.82	2.62	0.88
27.4. types of soil	2.81	0.83	2.42	0.93
C. Sedimentation				
28. *Understand sedimentary processes and how rocks are formed from these processes*	3.53	0.66	3.57	0.60
28.1. erosion, transportation, and deposition by water, wind, and ice	3.52	0.63	3.48	0.63
28.2. sedimentary structures (e.g., bedding, ripples)	3.02	0.82	2.95	0.75
28.3. post-depositional processes (e.g., burial, lithification, cementation)	3.00	0.85	3.00	0.75
D. Earth Resources				
29. *Analyze the interrelationships between civilization and Earth materials as resources*	3.12	0.85	3.26	0.86
29.1. fuel resources (e.g., coal, petroleum, uranium)	3.14	0.83	3.27	0.79
29.2. mineral resources (e.g., aluminum, iron, gold)	3.04	0.83	3.10	0.84
29.3. sediments as resources (e.g., sand, gravel, limestone placers)	2.82	0.82	2.84	0.89
29.4. geographic distribution of resources vs. population patterns	2.73	0.95	2.84	1.00
29.5. issues related to the extraction and reclamation of resources	2.88	0.92	2.91	0.92
E. Landscapes				
30. *Understand the processes by which a landscape evolves*	3.30	0.69	3.43	0.74
30.1. mass wasting (e.g., landslides, avalanches)	2.98	0.77	3.17	0.77
30.2. running water	3.35	0.70	3.42	0.71
30.3. groundwater (e.g., karst topography, permafrost)	3.13	0.78	3.18	0.79
30.4. waves and currents (e.g., beaches, sea caves)	3.02	0.79	2.99	0.77
30.5. glaciers	3.11	0.76	3.06	0.80
30.6. wind	3.01	0.82	2.87	0.85
30.7. sedimentary processes in various geomorphic environments (e.g., marine, desert, arctic)	2.77	0.80	2.84	0.90
31. *Recognize and interpret geologic features as represented by photographs, topographic and geologic maps*	3.09	0.83	3.16	0.76

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	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
III. THE ROCK CYCLE (cont.)				
32. *Analyze the interrelationships between civilization and internal and external processes that shape the land*	3.01	0.84	3.17	0.80
32.1. natural hazards (e.g., landslides, floods, earthquakes, volcanic action)	3.11	0.79	3.27	0.81
32.2. civilization's influence on weathering and erosion (e.g., acid rain, road building, mining practices	3.08	0.85	3.07	0.93
32.3. civilizations influence on soils (e.g., urbanization, irrigation, soil conservation)	2.94	0.93	2.92	0.93
IV. HISTORY OF THE EARTH				
A. The Record in the Rocks				
35. *Understand the basic assumptions of stratigraphic correlation*	3.16	0.75	3.39	0.73
35.1. basic principles (e.g., original horizontality, superposition, cross-cutting relationships)	3.13	0.79	3.40	0.76
35.2. interpretation of sequence of events from a map and/or profile	2.99	0.80	3.12	0.80
36. *Understand how rocks provide a record of the history of the Earth*	3.28	0.80	3.64	0.58
36.1. early history of the Earth	2.97	0.86	3.08	0.75
36.2. ancient continents including Gondwanaland and Pangea	2.90	0.91	2.98	0.90
36.3. the evolution of North America (e.g., mountain-building, accretion, basin formation)	2.93	0.81	3.07	0.77
36.4. methods of fossilization	2.95	0.82	2.90	0.88
36.5. the development of life	2.86	0.90	3.25	0.82
36.6. mass extinctions	2.86	0.88	3.13	0.77
36.7. paleoenvironments and paleoclimates	2.61	0.94	3.11	0.78
B. Time and How It Is Measured				
37. *Understand how time is measured*	3.16	0.77	3.72	0.48
37.1. relative vs. absolute time	3.01	0.85	3.64	0.60
37.2. methods used to measure absolute time (e.g., radioactive isotopes)	2.98	0.88	3.46	0.69
37.3. methods used to measure relative time (e.g., superposition, fossils)	3.07	0.82	3.47	0.67
37.4. the geologic time scale	3.08	0.87	3.46	0.67
V. THE WATER CYCLE				
A. Unique Properties of Water				
40. *Understand the structure of the water molecule as it relates to its special properties (e.g., high specific heat, polarity, density changes)*	2.99	0.89	3.03	0.90

	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
V. THE WATER CYCLE (cont.)				
B. The Hydrologic Cycle				
41. *Understand the paths that water follows as it moves through the water cycle and the energy transfers that accompany this movement*	3.49	0.70	3.52	0.65
41.1. phase changes (e.g., evaporation, condensation and precipitation)	3.48	0.65	3.33	0.77
41.2. surface processes (e.g., runoff, infiltration, transpiration)	3.34	0.69	3.35	0.73
41.3. alteration of the cycle by human activities (e.g., deforestation, urban development)	3.23	0.81	3.22	0.80
C. Weather and Climate				
42. *Understand the systematic development and movement of weather patterns and phenomena*	3.61	0.57	3.30	0.74
42.1. evolution of the atmosphere	2.60	0.93	2.82	0.92
42.2. structure and composition of the atmosphere	3.21	0.73	3.01	0.78
42.3. temperature: seasonal variations, heat budget, albedo, latitude, elevation	3.13	0.73	3.05	0.83
42.4. water in the air: specific and relative humidity, dewpoint (frost-point)	3.40	0.67	2.88	0.98
42.5. atmospheric circulation (e.g., Coriolis effect, global and local winds, high and low pressure systems)	3.43	0.70	3.16	0.80
42.6. fronts, storms, and severe weather events	3.50	0.62	3.00	0.94
42.7. types of clouds and precipitation	3.28	0.75	2.66	0.96
42.8. weather map analysis	3.30	0.72	2.55	0.99
42.9. interpretation of atmospheric data	3.13	0.73	2.53	0.89
42.10. interactions of the ocean and the atmosphere (e.g., el Niño, carbon dioxide cycle)	3.03	0.83	3.06	0.86
43. *Analyze the natural factors contributing to climate*	3.28	0.65	3.29	0.72
43.1. global circulation of the atmosphere and the oceans	3.18	0.71	3.28	0.75
43.2. climatic zones caused by latitude, altitude and topography, bodies of water, and prevailing winds	3.22	0.68	3.22	0.75
43.3. long- and short-term climate change	2.93	0.77	3.15	0.75
43.4. variations in solar output	2.67	0.79	2.65	0.93
43.5. volcanic eruptions and meteorite impact	2.83	0.80	2.86	0.77
43.6. changes due to tectonic environment (e.g., ice ages, rain, shadow deserts)	2.86	0.81	2.94	0.78
44. *Understand the interrelationships between civilization and weather and climate*	3.34	0.72	3.19	0.80
44.1. air pollution: gases, particulates, secondary air pollution	3.37	0.77	3.22	0.79
44.2. acid precipitation (e.g., rain, snow, fog)	3.32	0.80	3.00	0.85
44.3. urban climates (e.g., heat islands, smog)	3.09	0.84	2.85	0.81
44.4. ozone as a pollutant	3.23	0.82	2.84	0.80

	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
V. **THE WATER CYCLE (cont.)**				
44.5. changes to the protective ozone layer	3.41	0.74	3.09	0.72
44.6. effects of greenhouse gases	3.44	0.71	3.20	0.70
44.7. pollution control (benefits, methods, costs, regulations)	3.23	0.86	2.86	0.91
44.8. power generated by wind	2.73	0.96	2.35	0.95
44.9. weather modification (e.g., cloud seeding, hail suppression)	2.58	0.91	2.18	0.93
D. **Waters of the Land**				
45. *Understand the processes by which water moves on and beneath the Earth's surface*	3.36	0.70	3.54	0.63
45.1. runoff and infiltration	3.24	0.69	3.32	0.71
45.2. rivers: discharge, current, load, grades, intermittent streams	3.14	0.80	3.33	0.68
45.3. floods	2.96	0.79	3.13	0.78
45.4. lakes and playas	2.69	0.83	2.65	0.81
45.5. groundwater and water table	3.37	0.71	3.53	0.68
45.6. aquifers	3.21	0.78	3.42	0.66
45.7. porosity and permeability	3.20	0.76	3.31	0.80
45.8. artesian/non-artesian wells	2.77	0.91	2.84	0.87
45.9. springs	2.79	0.89	2.77	0.86
45.10. geysers and hot springs	2.66	0.90	2.54	0.89
46. *Analyze the interrelationships between civilization and water resources*	3.27	0.79	3.20	0.80
46.1. management and conservation of water as a resource	3.36	0.80	3.21	0.79
46.2. water pollution	3.40	0.71	3.20	0.80
46.3. sewage and wastewater treatment	3.05	0.87	2.75	0.89
46.4. wells and effects of groundwater depletion	3.11	0.81	3.15	0.81
46.5. effects of urbanization	2.99	0.87	3.01	0.87
46.6. hydroelectric) power	2.77	0.82	2.35	0.91
46.7. aquifers and surface reservoirs	2.97	0.86	2.94	0.81
46.8. land development near rivers, lakes, and floodplains	2.92	0.93	2.95	0.91
46.9. recreational use and aesthetic considerations	2.57	0.99	2.27	0.99

	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
V. **THE WATER CYCLE (cont.)**				
E. **Water in the Ocean**				
47. *Understand the physical and chemical characteristics and processes of the oceans*	3.11	0.71	3.33	0.75
47.1. origin and evolution of the oceans	2.67	0.92	2.95	0.91
47.2. geographic locations of major oceans and seas	3.03	0.86	3.01	0.97
47.3. variations in salinity, temperature, and density	2.81	0.85	2.85	0.92
47.4. chemical cycles (dissolved ions)	2.37	0.90	2.74	0.89
47.5. nutrient cycles and upwellings	2.63	0.93	2.87	0.90
47.6. oceanic circulation patterns	2.93	0.81	3.09	0.88
47.7. tides, waves, and currents	3.13	0.74	3.16	0.81
47.8. nearshore waters including estuaries	2.81	0.93	2.87	0.89
47.9. energy and matter exchange with atmosphere	2.84	0.82	2.79	0.90
48. *Understand and analyze the interrelationships between the waters of the oceans and the solid Earth*	2.94	0.72	3.05	0.83
48.1. maps and profiles of the oceans, bays, estuaries, and shorelines	2.62	0.89	2.60	0.82
48.2. erosional and depositional processes	2.97	0.80	3.05	0.75
48.3. sedimentation: chemical and mechanical	2.85	0.81	2.98	0.81
48.4. reefs and atolls	2.48	0.87	2.64	0.87
48.5. hydrothermal convection at mid-ocean ridges	2.63	0.92	2.66	0.86
48.6. importance of ocean water at plate boundaries	2.55	0.98	2.47	0.84
49. *Analyze the interrelationships between civilization and the oceans*	3.04	0.86	3.10	0.85
49.1. ocean pollution	3.13	0.88	3.03	0.95
49.2. beach erosion and shoreline stabilization	2.99	0.90	3.00	0.85
49.3. coastal and offshore development issues	2.78	0.89	2.78	0.93
49.4. energy from the sea: tides, waves, currents, upwellings	2.87	0.91	2.52	1.00
49.5. management of resources from the ocean	2.95	0.90	2.70	0.98
49.6. causes and effects of sea level changes	2.76	0.90	2.98	0.85
F. **Ice**				
50. *Understand the processes that form and transform ice on the Earth*	3.06	0.74	3.11	0.76
50.1. glaciers, ice caps, and permafrost	3.00	0.84	3.06	0.77
50.2. formation and movement of bodies of ice	2.84	0.86	2.91	0.81

	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
V. **THE WATER CYCLE (cont.)**				
50.3. changes in climate, sea level, and history of ice advances and retreats	2.85	0.80	3.12	0.73
50.4. erosional and depositional processes	2.95	0.85	2.79	0.78
51. *Understand the interrelationships between civilizations and the cryospheres (ice)*	2.48	0.92	2.60	0.94
51.1. development on permafrost (e.g., Alaskan pipeline)	2.38	0.88	2.40	0.87
51.2. land bridges	2.37	0.88	2.38	0.91
51.3. hazards of ice (e.g., icebergs)	2.21	0.95	2.09	0.98
51.4. ice as a resource	2.24	0.90	2.09	0.98
VI. **THE EARTH IN SPACE**				
A. Earth-Moon-Sun				
54. *Understand the consequences of the Earth's characteristics and motions*	3.66	0.53	3.44	0.68
54.1. shape and size (e.g., latitude, longitude)	3.53	0.67	3.23	0.83
54.2. rotation (e.g., length of day, time zones)	3.58	0.63	3.30	0.81
54.3. revolution (e.g., length of year)	3.56	0.64	3.25	0.85
54.4. tilt (e.g., seasons)	3.62	0.60	3.28	0.80
54.5. albedo, heat budget	2.94	0.81	2.97	0.87
55. *Analyze the relationships between the Earth, Moon, and Sun*	3.45	0.69	3.16	0.86
55.1. phases of the Moon	3.31	0.76	3.00	0.91
55.2. tides	3.28	0.80	3.13	0.80
55.3. eclipses	3.19	0.85	2.74	0.96
B. Solar System				
56. *Characterize and relate the components of the solar system in terms of composition, size, motions, and history*	3.34	0.78	3.28	0.78
56.1. origin of the solar system	3.07	0.91	3.15	0.84
56.2. the Sun: structure, composition, and features	3.13	0.92	2.87	0.83
56.3. laws of planetary motion	3.05	0.93	2.90	0.92
56.4. planets and natural satellites	3.11	0.84	2.85	0.88
56.5. surface and history of nearby bodies (e.g., Moon, Mars, Venus)	2.95	0.85	2.87	0.91
56.6. meteoroids, asteroids, and comets	2.93	0.90	2.74	0.88
56.7. ancient astronomy	2.41	1.01	1.94	0.93

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	Teachers		Teacher Educators	
	Mean	SD	Mean	SD
VI. THE EARTH IN SPACE (cont.)				
C. **Stars**				
57. *Understand the characteristics of stars and the processes that occur within them*	3.10	0.84	2.74	1.01
57.1. properties of stars (e.g., mass, spectral class, magnitude)	2.85	0.86	2.57	0.95
57.2. relative distances and velocities (e.g., parallax, Doppler shift)	2.79	0.91	2.53	0.99
57.3. stages in the life cycles of stars (e.g., nebula, main sequence, giants, dwarfs, black holes)	2.91	0.94	2.65	1.00
57.4. H-R diagram	2.71	0.97	2.27	1.06
58. *Understand the interrelationships between civilization and astronomical objects*	2.86	0.89	2.34	0.90
58.1. constellations and star charts	2.67	0.90	2.09	0.89
58.2. space exploration	3.02	0.84	2.41	0.99
58.3. planetariums	2.59	0.88	1.96	0.85
D. **Galaxies and the Universe**				
59. *Understand the structure of the Milky Way and other galaxies*	2.93	0.91	2.72	0.97
59.1. multiple star systems (e.g., binaries, clusters)	2.59	0.91	2.33	0.91
59.2. characteristics of galaxies	2.77	0.91	2.48	0.96
59.3. relative distances and motions of objects in the universe	2.83	0.88	2.70	1.03
59.4. quasars	2.44	0.94	2.22	0.90
59.5. structure of the universe (e.g., curvature, gravitational/time relationship)	2.54	0.94	2.52	1.10
59.6. hypotheses of the origin and evolution of the universe	2.94	0.96	2.91	1.01

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Appendix H

Mean Importance Ratings: Subgroups of Respondents

	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
I. BASIC SCIENTIFIC PRINCIPLES								
A. Scientific Methodology and Philosophy								
1. *Understand the methods of scientific problem solving*	3.67	3.81	3.80	3.68	3.77	3.73	3.82	3.70
1.1. facts, models, theories, hypotheses, and laws	3.32	3.34	3.49	3.41	3.28	3.41	3.46	3.37
1.2. process skills (e.g., problem identification, observation, measurement, inference, classification)	3.68	3.62	3.62	3.59	3.77	3.58	3.66	3.61
1.3. investigative and experimental methods	3.51	3.43	3.48	3.31	3.49	3.41	3.45	3.41
2. *Understand the importance of the study of Earth and Space Science*	3.69	3.59	3.71	3.61	3.69	3.63	3.66	3.64
2.1. the significance of Earth and Space Science in everyday life (e.g., social/environmental issues, aesthetics, recreation)	3.51	3.49	3.51	3.45	3.58	3.46	3.50	3.48
2.2. integration of Earth and Space Science in other science fields	3.14	3.23	3.35	3.20	3.18	3.24	3.21	3.23
2.3. the interrelatedness of Earth and Space Science and other fields of study (e.g., history, literature, art)	2.84	2.83	2.79	2.74	2.83	2.79	2.76	2.82
2.4. careers in Earth and Space Sciences and related fields	2.88	2.86	2.82	2.84	3.00	2.80	2.93	2.85
3. *Demonstrate knowledge of historical roots of science and the contributions made by major historical figures as well as members of cultural/ethnic groups (e.g., ancient Chinese and Greek astronomers, Galileo, Darwin, Curie, Hutton)*	2.55	2.40	2.71	2.64	2.60	2.55	2.61	2.54
B. Mathematics, Measurement, and Data Manipulation								
4. *Understand the use of various measurement systems*	3.62	3.41	3.57	3.53	3.55	3.52	3.51	3.54
4.1. English system	2.90	2.70	3.03	2.81	2.87	2.84	2.68	2.95
4.2. metric (SI) system	3.75	3.54	3.57	3.71	3.70	3.63	3.59	3.69
4.3. exponential notation	3.11	2.88	2.97	3.16	3.09	3.00	2.95	3.04
4.4. map scales	3.47	3.39	3.30	3.33	3.50	3.33	3.33	3.41
4.5. significant figures	2.82	2.63	2.95	2.94	2.77	2.84	2.76	2.81
4.6. scales specific to Earth and Space Science	3.42	3.13	3.28	3.32	3.28	3.29	3.11	3.34
5. *Compile, evaluate, and interpret data, including analysis of errors*	3.49	3.24	3.22	3.33	3.30	3.34	3.16	3.38
5.1. compilation and interpretation of data (e.g., text, graphs, charts, tables, photographs, and maps)	3.62	3.38	3.33	3.33	3.46	3.41	3.33	3.47
5.2. analysis and evaluation of data	3.54	3.21	3.26	3.22	3.34	3.30	3.19	3.35
5.3. national/local databases	2.55	2.47	2.48	2.41	2.54	2.46	2.40	2.52
5.4. observational and experimental variation: sources, precision, accuracy, and experimental error	2.96	2.83	2.87	3.07	2.84	2.96	2.88	2.91
6. *Understand and interpret maps and photographs*	3.44	3.33	3.46	3.34	3.48	3.35	3.34	3.42
6.1. map projections	2.87	2.95	3.02	2.83	3.06	2.85	2.98	2.89
6.2. legends, symbols, and scales	3.32	3.28	3.34	3.09	3.44	3.18	3.28	3.26

Note. NE = Northeast; C = Central; S = Southern; FW = Far West

	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
I. **BASIC SCIENTIFIC PRINCIPLES (cont.)**								
6.3. aerial and satellite photographs	2.86	2.85	2.93	2.87	2.96	2.83	2.68	2.93
6.4. topographic maps including bathymetric maps	3.35	3.18	3.21	3.22	3.25	3.24	3.06	3.34
6.5. geologic maps	3.13	2.99	3.16	3.14	3.15	3.08	3.06	3.11
6.6. weather maps	3.33	3.16	3.18	2.94	3.30	3.10	3.29	3.14
C. **Laboratory/Field Procedures and Safety**								
7. *Understand the proper methods involved in using laboratory and field materials and equipment in a safe and appropriate manner*	3.51	3.51	3.52	3.56	3.63	3.48	3.53	3.52
7.1. use of chemicals and equipment (e.g., acids, glassware)	3.27	3.29	3.40	3.38	3.43	3.28	3.38	3.31
7.2. preparation, storage, and disposal of materials	3.16	3.19	3.31	3.26	3.34	3.17	3.35	3.18
7.3. safety procedures for laboratory and field work	3.55	3.49	3.54	3.49	3.62	3.48	3.56	3.51
7.4. laboratory and field hazards	3.42	3.40	3.57	3.43	3.57	3.40	3.45	3.45
8. *Understand the appropriate use of equipment/instruments for measurement and observation in Earth and Space Science*	3.34	3.10	3.10	3.16	3.37	3.11	3.18	3.19
8.1. Earth's interior (e.g., seismographs)	3.08	2.96	3.02	2.93	3.13	2.94	3.04	2.99
8.2. surface of the Earth (e.g., maps, satellite images, microscopes)	3.18	3.09	3.13	3.04	3.27	3.05	3.08	3.14
8.3. oceans and ocean floor (e.g., submersibles, sonar)	2.78	2.68	2.82	2.70	2.93	2.66	2.86	2.70
8.4. Earth's atmosphere (e.g., barometers, anemometers)	3.26	3.06	3.00	2.83	3.22	2.98	3.06	3.07
8.5. astronomical objects (e.g., telescopes, spectroscopes)	3.00	2.82	2.93	2.70	3.00	2.81	2.95	2.85
9. *Understand computer and related technologies as they apply to investigative activities*	3.05	2.99	2.97	3.01	3.05	2.99	2.94	3.04
9.1. spreadsheets	2.67	2.47	2.49	2.59	2.64	2.52	2.59	2.52
9.2. generation of graphs, maps, and profiles	2.89	2.84	2.79	2.88	2.99	2.80	2.88	2.83
9.3. simulations including videodisc and CD-ROM	2.67	2.62	2.69	2.62	2.83	2.57	2.63	2.65
9.4. interactive systems: using the computer to collect/analyze data	2.82	2.72	2.79	2.76	2.84	2.74	2.73	2.78
9.5. accessing national databases and on-line services	2.48	2.38	2.54	2.50	2.56	2.43	2.44	2.45
D. **Biological, Chemical, and Physical Processes**								
10. *Understand fundamental biological, chemical, and physical processes as they apply to the study of Earth and Space Science*	3.37	3.37	3.36	3.46	3.38	3.40	3.42	3.38
10.1. characteristics of life forms	2.91	2.93	2.97	3.03	3.00	2.93	3.03	2.90
10.2. evolutionary processes (e.g., natural selection, mutation)	3.00	2.89	3.03	3.20	3.11	2.99	3.04	3.02
10.3. metabolic processes (e.g., photosynthesis, respiration)	2.64	2.65	2.80	2.72	2.83	2.64	2.79	2.62
10.4. ecological interrelationship (e.g., energy flow, bio-geochemical cycles)	3.00	2.99	3.12	3.04	3.11	3.00	3.06	2.99

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	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
I. BASIC SCIENTIFIC PRINCIPLES (cont.)								
10.5. characteristics of chemical bonds	2.78	2.78	2.72	2.99	2.74	2.84	2.84	2.80
10.6. types and rates of chemical reactions	2.52	2.54	2.43	2.74	2.60	2.54	2.61	2.53
10.7. mechanics (e.g., motion, gravity, force)	3.11	3.06	2.98	3.14	3.10	3.07	3.13	3.07
10.8. characteristics of waves (e.g., light, sound, water, seismic)	3.14	2.99	3.00	3.06	3.09	3.03	3.09	3.03
E. Matter and Energy								
11. *Understand the patterns, inter- and intrarelationships of matter and energy*	3.36	3.27	3.25	3.38	3.27	3.33	3.24	3.34
11.1. physical/chemical properties (e.g., states, reactivity, specific gravity, porosity)	3.17	3.21	3.05	3.18	3.13	3.16	3.18	3.15
11.2. particulate nature of matter (e.g., atoms, ions, isotopes, molecules)	3.06	3.12	3.05	3.26	3.05	3.14	3.17	3.10
11.3. organization of matter (e.g., elements, compounds, substances, mixtures, solutions, colloids)	3.03	3.25	3.02	3.18	2.93	3.19	3.17	3.11
11.4. physical vs. chemical change	3.18	3.27	3.14	3.14	3.12	3.21	3.19	3.19
11.5. forms of energy/energy transformations (e.g., kinetic, potential, thermal, electrical)	3.03	2.89	2.94	3.03	2.89	3.00	3.08	2.92
11.6. conservation of mass/energy	3.09	3.03	3.03	3.08	3.00	3.08	3.10	3.04
11.7. force (e.g., gravitational, pressure, mass vs. weight, buoyancy, friction)	3.16	3.08	3.08	3.15	3.07	3.13	3.06	3.16
12. *Understand issues associated with the use and production of various energy sources (e.g., fossil fuels, nuclear, hydroelectric, geothermal)*	3.40	3.49	3.34	3.49	3.54	3.39	3.39	3.46
12.1. renewable vs. nonrenewable sources	3.31	3.47	3.33	3.44	3.51	3.34	3.35	3.40
12.2. tradeoffs associated with various sources	3.10	3.38	3.19	3.32	3.38	3.20	3.17	3.28
12.3. conservation	3.38	3.49	3.44	3.48	3.59	3.39	3.43	3.45
F. Heat and Thermodynamics								
13. *Understand the transfer and measurement of heat and the laws of thermodynamics*	2.99	3.00	3.06	3.06	3.01	3.02	2.99	3.05
13.1. temperature scales and measurement	3.17	3.17	3.13	3.01	3.23	3.08	3.05	3.16
13.2. temperature vs. heat	3.06	2.94	3.02	2.94	3.05	2.96	2.94	3.00
13.3. heat transfer mechanisms (conduction, convection, radiation)	3.26	3.12	3.06	3.11	3.21	3.12	3.11	3.16
13.4. heat sources (e.g., radioactive decay, friction)	2.99	2.93	2.86	3.06	2.93	2.97	2.86	3.00
13.5. thermal expansion and contraction	2.73	2.72	2.70	2.79	2.74	2.72	2.71	2.74
13.6. laws of thermodynamics	2.60	2.72	2.73	2.66	2.65	2.67	2.68	2.65
13.7. heat capacity and specific heat	2.79	2.64	2.52	2.56	2.60	2.65	2.64	2.66
13.8. phase changes	3.03	3.04	2.86	2.85	2.98	2.94	2.90	2.96

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	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
I. **BASIC SCIENTIFIC PRINCIPLES (cont.)**								
13.9. kinetic molecular theory	2.62	2.56	2.48	2.61	2.60	2.55	2.61	2.53
13.10. temperature, pressure, volume relationships	3.01	2.90	2.97	3.06	2.94	3.00	3.00	2.97
G. Atomic and Nuclear Structure								
14. *Understand the structure of atoms*	3.10	3.16	3.21	3.35	3.15	3.21	3.22	3.21
14.1. historical development of atomic models	2.12	2.15	2.30	2.35	2.10	2.26	2.37	2.19
14.2. structure of the atom including subatomic particles (e.g., electrons, protons, neutrons, neutrinos)	2.88	2.99	3.02	3.15	3.01	2.99	3.04	2.99
14.3. atomic mass, atomic number, mass number, isotopes, and ions	2.97	3.06	3.05	3.28	2.99	3.11	3.10	3.09
14.4. physical and chemical properties related to electron configuration (e.g., atomic valence, reactivity, periodic trends)	2.61	2.65	2.65	2.89	2.51	2.76	2.70	2.69
15. *Understand nuclear reactions*	2.76	2.53	2.83	3.00	2.78	2.76	2.64	2.83
15.1. nuclear forces and binding energy	2.40	2.40	2.60	2.65	2.45	2.51	2.48	2.51
15.2. characteristic properties and effects of radiation	2.64	2.65	2.76	2.77	2.72	2.69	2.60	2.73
15.3. artificial and natural radiation	2.55	2.42	2.54	2.72	2.55	2.55	2.40	2.61
15.4. half-life of radioactive isotopes	3.00	2.80	2.92	3.01	2.79	2.98	2.71	3.02
15.5. nuclear reactions (e.g., transmutation, fission, fusion)	2.84	2.59	2.83	2.83	2.70	2.71	2.62	2.73
II. **TECTONICS**								
A. Plate Tectonics: The Unifying Theory								
18. *Understand the unifying theory of plate tectonics*	3.79	3.71	3.71	3.76	3.77	3.74	3.65	3.77
18.1. sources of evidence (e.g., seismic, magnetic, fossil)	3.62	3.45	3.38	3.59	3.54	3.51	3.45	3.54
18.2. plate boundaries: convergent, divergent, transform	3.62	3.55	3.54	3.63	3.57	3.59	3.52	3.60
18.3. mantle convection	3.44	3.26	3.25	3.25	3.30	3.31	3.27	3.32
18.4. topography of the sea floor	3.24	3.23	3.29	3.20	3.20	3.25	3.22	3.24
18.5. hot spots	3.22	3.10	3.08	3.15	3.15	3.14	3.08	3.16
18.6. location on the Earth of geographical features that have tectonic significance	3.60	3.53	3.44	3.61	3.55	3.55	3.45	3.57
18.7. distribution and types of earthquakes and volcanoes (e.g., "Ring of Fire")	3.55	3.56	3.48	3.60	3.57	3.54	3.51	3.54
B. Mountain-forming Processes								
19. *Understand the processes by which the crust is deformed*	3.55	3.55	3.51	3.45	3.54	3.51	3.35	3.60
19.1. compression and extension of the crust	3.35	3.35	3.33	3.31	3.33	3.34	3.31	3.35
19.2. geologic structures (e.g., folds, faults, joints)	3.48	3.45	3.51	3.34	3.41	3.45	3.33	3.49

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	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
II. **TECTONICS (cont.)**								
19.3. igneous and metamorphic processes	3.44	3.43	3.32	3.35	3.35	3.40	3.33	3.43
19.4. isostatic adjustment	3.03	3.01	2.92	3.01	2.95	3.01	2.92	3.05
C. **The Earth's Interior**								
20. *Understand how earthquakes occur and provide information about the Earth's interior*	3.56	3.62	3.49	3.53	3.63	3.52	3.57	3.57
20.1. earthquake, magnitude, and intensity	3.41	3.43	3.30	3.43	3.52	3.34	3.41	3.41
20.2. seismograms and seismic waves	3.36	3.34	3.17	3.29	3.37	3.27	3.37	3.28
20.3. internal structure of the Earth	3.43	3.44	3.32	3.41	3.43	3.39	3.45	3.39
20.4. composition of the Earth	3.26	3.40	3.22	3.33	3.39	3.27	3.34	3.30
20.5. heat sources within the Earth	3.08	3.19	3.03	3.20	3.22	3.09	3.16	3.12
20.6. location of resources and plate boundaries	3.25	3.33	3.21	3.30	3.34	3.24	3.28	3.27
21. *Understand the origin and effects of the Earth's magnetic field*	2.89	2.88	2.90	2.91	2.93	2.88	2.83	2.91
21.1. possible causes (e.g., dynamo theory)	2.65	2.66	2.60	2.79	2.65	2.68	2.64	2.68
21.2. rock magnetism	2.86	2.80	2.78	2.94	2.88	2.83	2.77	2.88
21.3. geomagnetic reversals	2.93	2.84	2.84	2.93	2.89	2.88	2.80	2.94
21.4. Van Allen belts	2.34	2.46	2.46	2.36	2.57	2.33	2.52	2.35
21.5. auroras	2.35	2.57	2.52	2.32	2.58	2.38	2.55	2.37
III. **THE ROCK CYCLE**								
A. **Earth Materials**								
24. *Understand the characteristics of minerals and the methods used to identify them*	3.36	3.53	3.34	3.44	3.44	3.40	3.35	3.47
24.1. definition	3.13	3.23	3.19	3.17	3.17	3.18	3.11	3.24
24.2. crystal structure	2.78	2.74	2.90	2.94	2.88	2.81	2.74	2.86
24.3. relationship between structure and physical properties (e.g., hardness, cleavage, specific gravity)	3.26	3.36	3.27	3.19	3.32	3.25	3.21	3.32
24.4. mineral classes (e.g., silicates, carbonates, elements)	2.77	2.94	2.93	2.97	2.91	2.88	2.90	2.89
25. *Understand the cycling of Earth materials*	3.49	3.51	3.42	3.56	3.49	3.50	3.53	3.51
26. *Understand the processes by which rocks are formed by crystallization*	3.34	3.32	3.26	3.41	3.30	3.34	3.27	3.37
26.1. formation of and crystallization from a magma	3.24	3.33	3.15	3.20	3.22	3.24	3.16	3.27
26.2. metamorphic processes	3.23	3.31	3.19	3.21	3.23	3.24	3.26	3.25
26.3. characteristics of igneous and metamorphic rocks	3.38	3.43	3.26	3.24	3.35	3.32	3.26	3.38
26.4. evidence for composition of the Earth's interior	3.05	3.05	2.95	3.17	3.15	3.02	3.04	3.08

	Geographic Region				Sex		*Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
III. **THE ROCK CYCLE (cont.)**								
B. Weathering								
27. *Understand the processes of weathering and soil formation*	3.48	3.49	3.48	3.39	3.50	3.44	3.33	3.53
27.1. physical processes	3.38	3.45	3.32	3.31	3.40	3.35	3.18	3.46
27.2. chemical processes	3.36	3.43	3.32	3.31	3.39	3.35	3.16	3.45
27.3. soil profiles	2.89	2.93	2.94	2.85	2.99	2.86	2.84	2.91
27.4. types of soil	2.68	2.78	2.85	2.61	2.88	2.66	2.77	2.70
C. Sedimentation								
28. *Understand sedimentary processes and how rocks are formed from these processes*	3.60	3.58	3.44	3.52	3.54	3.54	3.45	3.59
28.1. erosion, transportation, and deposition by water, wind, and ice	3.56	3.51	3.40	3.48	3.55	3.47	3.39	3.56
28.2. sedimentary structures (e.g., bedding, ripples)	2.97	3.09	3.08	3.01	3.11	3.00	2.98	3.05
28.3. post depositional processes (e.g., burial, lithification, cementation)	3.01	3.10	3.02	2.97	2.99	3.04	2.90	3.08
D. Earth Resources								
29. *Analyze the interrelationships between civilization and Earth materials as resources*	3.13	3.20	3.26	3.27	3.29	3.17	3.14	3.24
29.1. fuel resources (e.g., coal, petroleum, uranium)	3.08	3.28	3.27	3.24	3.28	3.18	3.23	3.21
29.2. mineral resources (e.g., aluminum, iron, gold)	3.01	3.17	3.11	3.11	3.17	3.06	3.13	3.10
29.3. sediments as resources (e.g., sand, gravel, limestone placers)	2.78	3.01	2.92	2.86	2.99	2.85	2.90	2.89
29.4. geographic distribution of resources vs. population patterns	2.73	2.90	2.85	2.82	2.91	2.78	2.83	2.81
29.5. issues related to the extraction and reclamation of resources	2.82	3.03	2.98	2.87	2.94	2.91	2.92	2.94
E. Landscapes								
30. *Understand the processes by which a landscape evolves*	3.40	3.33	3.34	3.33	3.35	3.35	3.15	3.45
30.1. mass wasting (e.g., landslides, avalanches)	3.10	3.00	3.05	3.08	3.06	3.06	2.87	3.17
30.2. running water	3.48	3.33	3.31	3.35	3.32	3.39	3.16	3.48
30.3. groundwater (e.g., karst topography, permafrost)	3.22	3.19	3.21	3.09	3.26	3.14	3.07	3.24
30.4. waves and currents (e.g., beaches, sea caves)	3.09	3.00	3.13	2.99	3.12	3.02	2.98	3.08
30.5. glaciers	3.23	3.14	2.98	3.01	3.12	3.09	2.96	3.19
30.6. wind	2.98	3.05	3.05	2.93	3.11	2.95	2.96	3.05
30.7. sedimentary processes in various geomorphic environments (e.g., marine, desert, arctic)	2.83	2.87	2.80	2.88	2.82	2.85	2.80	2.87
31. *Recognize and interpret geologic features as represented by photographs, topographic and geologic maps*	3.13	3.15	3.07	3.19	3.26	3.09	3.03	3.19

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	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
III. THE ROCK CYCLE (cont.)								
32. *Analyze the interrelationships between civilization and internal and external processes that shape the land*	3.06	3.14	3.08	3.10	3.23	3.04	2.91	3.18
32.1. natural hazards (e.g., landslides, floods, earthquakes, volcanic action)	3.18	3.19	3.15	3.28	3.28	3.17	3.01	3.30
32.2. civilization's influence on weathering and erosion (e.g., acid rain, road building, mining practices	3.05	3.15	3.10	3.16	3.20	3.08	2.91	3.19
32.3. civilizations influence on soils (e.g., urbanization, irrigation, soil conservation)	2.94	3.03	2.98	3.00	3.09	2.94	2.81	3.05
IV. HISTORY OF THE EARTH								
A. The Record in the Rocks								
35. *Understand the basic assumptions of stratigraphic correlation*	3.31	3.29	3.25	3.21	3.25	3.27	3.07	3.35
35.1. basic principles (e.g., original horizontality, superposition, cross-cutting relationships)	3.37	3.28	3.13	3.13	3.16	3.27	3.02	3.34
35.2. interpretation of sequence of events from a map and/or profile	3.15	3.10	3.03	2.97	3.09	3.06	2.93	3.14
36. *Understand how rocks provide a record of the history of the Earth*	3.40	3.37	3.48	3.40	3.38	3.42	3.32	3.43
36.1. early history of the Earth	3.05	3.01	2.98	3.06	3.00	3.03	3.08	2.97
36.2. ancient continents including Gondwanaland and Pangea	2.90	2.87	2.95	3.06	2.87	2.96	3.05	2.87
36.3. the evolution of North America (e.g., mountain-building, accretion, basin formation)	3.00	2.91	3.07	3.03	2.89	3.03	3.02	2.97
36.4. methods of fossilization	2.97	3.01	3.07	2.85	3.07	2.93	3.09	2.93
36.5. the development of life	2.92	2.94	3.13	3.10	3.07	2.98	3.05	2.98
36.6. mass extinctions	2.95	2.91	3.07	2.99	3.07	2.93	2.94	2.97
36.7. paleoenvironments and paleoclimates	2.76	2.73	2.90	2.79	2.81	2.77	2.81	2.76
B. Time and How It Is Measured								
37. *Understand how time is measured*	3.34	3.35	3.39	3.42	3.30	3.39	3.30	3.39
37.1. relative vs. absolute time	3.20	3.18	3.23	3.28	3.10	3.26	3.11	3.26
37.2. methods used to measure absolute time (e.g., radioactive isotopes)	3.13	3.05	3.20	3.16	3.01	3.17	3.06	3.16
37.3. methods used to measure relative time (e.g., superposition, fossils)	3.20	3.14	3.21	3.19	3.13	3.20	3.14	3.22
37.4. the geologic time scale	3.20	3.15	3.21	3.29	3.17	3.23	3.18	3.22
V. THE WATER CYCLE								
A. Unique Properties of Water								
40. *Understand the structure of the water molecule as it relates to its special properties (e.g., high specific heat, polarity, density changes)*	3.06	2.86	3.05	3.06	2.95	3.02	3.09	2.95

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	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
V. THE WATER CYCLE (cont.)								
B. The Hydrologic Cycle								
41. *Understand the paths that water follows as it moves through the water cycle and the energy transfers that accompany this movement*	3.59	3.44	3.54	3.51	3.49	3.53	3.51	3.51
41.1. phase changes (e.g., evaporation, condensation and precipitation)	3.52	3.43	3.46	3.35	3.53	3.41	3.49	3.43
41.2. surface processes (e.g., runoff, infiltration, transpiration)	3.45	3.29	3.39	3.27	3.40	3.33	3.38	3.35
41.3. alteration of the cycle by human activities (e.g., deforestation, urban development)	3.20	3.30	3.25	3.30	3.41	3.20	3.26	3.28
C. Weather and Climate								
42. *Understand the systematic development and movement of weather patterns and phenomena*	3.66	3.52	3.49	3.30	3.54	3.49	3.58	3.50
42.1. evolution of the atmosphere	2.62	2.67	2.69	2.87	2.68	2.71	2.89	2.63
42.2. structure and composition of the atmosphere	3.25	3.24	3.10	3.04	3.20	3.15	3.37	3.11
42.3. temperature: seasonal variations, heat budget, albedo, latitude, elevation	3.32	3.05	3.08	2.99	3.06	3.14	3.16	3.13
42.4. water in the air: specific and relative humidity, dewpoint (frost-point)	3.46	3.30	3.11	3.00	3.21	3.25	3.28	3.25
42.5. atmospheric circulation (e.g., Coriolis effect, global and local winds, high and low pressure systems)	3.49	3.42	3.23	3.19	3.33	3.35	3.46	3.32
42.6. fronts, storms, and severe weather events	3.57	3.47	3.21	2.99	3.31	3.34	3.38	3.35
42.7. types of clouds and precipitation	3.21	3.25	3.05	2.84	3.25	3.04	3.28	3.05
42.8. weather map analysis	3.40	3.11	2.95	2.69	3.20	3.01	3.15	3.07
42.9. interpretation of atmospheric data	3.13	3.05	2.84	2.71	3.10	2.89	2.99	2.95
42.10. interactions of the ocean and the atmosphere (e.g., el Niño, carbon dioxide cycle)	3.07	2.97	3.18	3.00	3.14	3.01	3.06	3.06
43. *Analyze the natural factors contributing to climate*	3.33	3.28	3.30	3.22	3.37	3.25	3.37	3.25
43.1. global circulation of the atmosphere and the oceans	3.32	3.18	3.25	3.10	3.24	3.20	3.36	3.16
43.2. climatic zones caused by latitude, altitude and topography, bodies of water, and prevailing winds	3.36	3.20	3.25	3.04	3.31	3.18	3.30	3.21
43.3. long- and short-term climate change	3.13	2.97	2.98	2.96	3.04	3.00	3.23	2.94
43.4. variations in solar output	2.74	2.65	2.77	2.70	2.89	2.64	2.89	2.65
43.5. volcanic eruptions and meteorite impact	2.95	2.79	2.92	2.84	2.98	2.84	2.90	2.88
43.6. changes due to tectonic environment (e.g., ice ages, rain, shadow deserts)	2.93	2.87	3.05	2.89	2.94	2.92	2.99	2.92
44. *Understand the interrelationships between civilization and weather and climate*	3.31	3.30	3.34	3.32	3.54	3.23	3.39	3.29
44.1. air pollution: gases, particulates, secondary air pollution	3.28	3.33	3.39	3.34	3.55	3.25	3.37	3.33
44.2. acid precipitation (e.g., rain, snow, fog)	3.26	3.21	3.18	3.21	3.46	3.13	3.31	3.19
44.3. urban climates (e.g., heat islands, smog)	3.03	3.04	3.00	3.04	3.28	2.94	3.16	3.00

	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
V. **THE WATER CYCLE (cont.)**								
44.4. ozone as a pollutant	3.17	3.11	3.20	3.03	3.33	3.05	3.28	3.09
44.5. changes to the protective ozone layer	3.37	3.33	3.30	3.21	3.51	3.23	3.36	3.30
44.6. effects of greenhouse gases	3.46	3.29	3.36	3.31	3.53	3.30	3.42	3.35
44.7. pollution control (benefits, methods, costs, regulations)	3.10	3.15	3.25	3.09	3.39	3.05	3.24	3.10
44.8. power generated by wind	2.71	2.67	2.77	2.59	3.01	2.56	2.81	2.62
44.9. weather modification (e.g., cloud seeding, hail suppression)	2.47	2.50	2.59	2.43	2.76	2.39	2.63	2.45
D. **Waters of the Land**								
45. *Understand the processes by which water moves on and beneath the Earth's surface*	3.51	3.47	3.43	3.33	3.51	3.41	3.27	3.50
45.1. runoff and infiltration	3.42	3.19	3.26	3.19	3.23	3.28	3.13	3.34
45.2. rivers: discharge, current, load, grades, intermittent streams	3.31	3.16	3.16	3.19	3.21	3.21	3.08	3.28
45.3. floods	3.14	3.01	2.95	3.01	3.06	3.02	2.90	3.11
45.4. lakes and playas	2.74	2.73	2.67	2.81	2.83	2.70	2.77	2.73
45.5. groundwater and water table	3.45	3.45	3.38	3.39	3.48	3.40	3.29	3.48
45.6. aquifers	3.39	3.25	3.25	3.27	3.31	3.29	3.16	3.35
45.7. porosity and permeability	3.39	3.19	3.18	3.14	3.28	3.22	3.04	3.32
45.8. artesian/non-artesian wells	2.87	2.78	2.80	2.83	2.83	2.81	2.75	2.87
45.9. springs	2.86	2.79	2.80	2.84	2.84	2.81	2.77	2.86
45.10. geysers and hot springs	2.64	2.67	2.62	2.76	2.78	2.63	2.64	2.69
46. *Analyze the interrelationships between civilization and water resources*	3.28	3.30	3.33	3.25	3.54	3.19	3.27	3.30
46.1. management and conservation of water as a resource	3.32	3.36	3.38	3.35	3.63	3.25	3.29	3.38
46.2. water pollution	3.32	3.42	3.42	3.26	3.63	3.25	3.37	3.36
46.3. sewage and wastewater treatment	3.08	3.04	3.03	2.86	3.30	2.89	3.06	2.98
46.4. wells and effects of groundwater depletion	3.15	3.19	3.26	3.00	3.36	3.06	3.09	3.18
46.5. effects of urbanization	3.03	3.04	3.08	3.00	3.33	2.93	3.05	3.02
46.6. hydro(electric) power	2.72	2.66	2.84	2.55	3.03	2.56	2.80	2.64
46.7. aquifers and surface reservoirs	3.03	2.98	3.03	2.96	3.15	2.94	2.93	3.04
46.8. land development near rivers, lakes, and floodplains	3.06	2.91	3.07	2.90	3.20	2.90	2.96	2.99
46.9. recreational use and aesthetic considerations	2.61	2.45	2.64	2.43	2.68	2.47	2.59	2.53

	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
V. **THE WATER CYCLE (cont.)**								
E. Water in the Ocean								
47. *Understand the physical and chemical characteristics and processes of the oceans*	3.18	3.10	3.28	3.23	3.23	3.18	3.30	3.15
47.1. origin and evolution of the oceans	2.75	2.59	2.87	2.99	2.81	2.77	2.96	2.72
47.2. geographic locations of major oceans and seas	2.94	3.10	3.15	2.99	3.30	2.94	3.13	3.03
47.3. variations in salinity, temperature, and density	2.77	2.84	2.92	2.81	2.99	2.76	2.94	2.82
47.4. chemical cycles (dissolved ions)	2.47	2.43	2.62	2.60	2.49	2.52	2.72	2.45
47.5. nutrient cycles and upwellings	2.69	2.65	2.77	2.81	2.70	2.73	2.87	2.68
47.6. oceanic circulation patterns	3.05	2.89	3.13	2.96	3.12	2.95	3.10	2.98
47.7. tides, waves, and currents	3.17	3.08	3.33	3.09	3.26	3.11	3.32	3.11
47.8. nearshore waters including estuaries	2.92	2.74	3.07	2.81	2.98	2.83	2.99	2.83
47.9. energy and matter exchange with atmosphere	2.95	2.80	2.87	2.81	2.95	2.83	2.89	2.86
48. *Understand and analyze the interrelationships between the waters of the oceans and the solid Earth*	3.05	2.98	3.07	2.99	3.00	3.02	2.99	3.03
48.1. maps and profiles of the oceans, bays, estuaries, and shorelines	2.68	2.68	2.80	2.57	2.69	2.67	2.72	2.65
48.2. erosional and depositional processes	3.13	2.99	3.15	2.87	3.07	3.01	2.93	3.09
48.3. sedimentation: chemical and mechanical	2.98	2.81	3.07	2.86	2.85	2.94	2.83	2.97
48.4. reefs and atolls	2.52	2.48	2.79	2.61	2.52	2.61	2.62	2.59
48.5. hydrothermal convection at mid-ocean ridges	2.78	2.51	2.70	2.65	2.65	2.66	2.66	2.69
48.6. importance of ocean water at plate boundaries	2.62	2.42	2.69	2.61	2.59	2.56	2.58	2.58
49. *Analyze the interrelationships between civilization and the oceans*	3.06	3.12	3.15	3.10	3.27	3.04	3.11	3.09
49.1. ocean pollution	3.23	3.02	3.15	3.09	3.33	3.05	3.15	3.12
49.2. beach erosion and shoreline stabilization	3.11	2.90	3.20	2.97	3.26	2.95	3.01	3.05
49.3. coastal and offshore development issues	2.86	2.73	2.89	2.90	3.07	2.75	2.83	2.84
49.4. energy from the sea: tides, waves, currents, upwellings	2.76	2.81	2.89	2.79	3.12	2.68	2.89	2.78
49.5. management of resources from the ocean	2.91	2.96	2.85	2.90	3.17	2.81	3.01	2.87
49.6. causes and effects of sea level changes	2.88	2.85	2.98	2.84	2.98	2.84	2.87	2.87
F. Ice								
50. *Understand the processes that form and transform ice on the Earth*	3.20	3.18	2.92	3.07	3.10	3.10	2.94	3.19
50.1. glaciers, ice caps, and permafrost	3.09	3.14	2.87	2.99	3.05	3.02	2.80	3.16
50.2. formation and movement of bodies of ice	3.03	2.90	2.72	2.83	2.80	2.91	2.71	2.98

	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
V. THE WATER CYCLE (cont.)								
50.3. changes in climate, sea level, and history of ice advances and retreats	3.05	2.98	2.90	2.98	2.91	3.00	2.89	3.02
50.4. erosional and depositional processes	3.08	3.00	2.80	2.79	2.89	2.94	2.79	3.01
51. *Understand the interrelationships between civilizations and the cryospheres (ice)*	2.59	2.59	2.51	2.66	2.73	2.53	2.45	2.63
51.1. development on permafrost (e.g., Alaskan pipeline)	2.49	2.43	2.44	2.46	2.64	2.38	2.38	2.48
51.2. land bridges	2.44	2.42	2.47	2.51	2.64	2.38	2.40	2.47
51.3. hazards of ice (e.g., icebergs)	2.24	2.33	2.21	2.19	2.36	2.20	2.23	2.25
51.4. ice as a resource	2.30	2.33	2.20	2.24	2.41	2.22	2.20	2.29
VI. THE EARTH IN SPACE								
A. Earth-Moon-Sun								
54. *Understand the consequences of the Earth's characteristics and motions*	3.68	3.58	3.50	3.57	3.69	3.55	3.63	3.60
54.1. shape and size (e.g., latitude, longitude)	3.58	3.42	3.32	3.30	3.52	3.38	3.42	3.47
54.2. rotation (e.g., length of day, time zones)	3.60	3.43	3.45	3.39	3.58	3.43	3.46	3.52
54.3. revolution (e.g., length of year)	3.58	3.40	3.42	3.37	3.59	3.39	3.44	3.49
54.4. tilt (e.g., seasons)	3.65	3.43	3.44	3.41	3.59	3.45	3.53	3.50
54.5 albedo, heat budget	3.11	2.84	2.84	2.99	2.89	2.97	2.93	3.00
55. *Analyze the relationships between the Earth, Moon, and Sun*	3.44	3.30	3.37	3.36	3.53	3.31	3.37	3.38
55.1. phases of the Moon	3.31	3.19	3.19	3.16	3.41	3.14	3.22	3.24
55.2. tides	3.26	3.22	3.34	3.17	3.37	3.20	3.30	3.25
55.3. eclipses	3.16	3.04	3.00	3.01	3.31	2.96	3.11	3.06
B. Solar System								
56. *Characterize and relate the components of the solar system in terms of composition, size, motions, and history*	3.33	3.28	3.34	3.30	3.34	3.30	3.38	3.29
56.1. origin of the solar system	3.10	3.05	3.18	3.09	3.11	3.09	3.17	3.10
56.2. the Sun: structure, composition, and features	3.10	3.14	3.03	2.93	3.09	3.04	3.15	3.04
56.3. laws of planetary motion	3.11	2.93	3.08	2.94	3.00	3.02	2.94	3.08
56.4. planets and natural satellites	3.00	3.11	3.15	2.91	3.18	2.99	3.16	3.04
56.5. surface and history of nearby bodies (e.g., Moon, Mars, Venus)	2.93	3.00	2.98	2.83	3.05	2.89	3.10	2.88
56.6. meteoroids, asteroids, and comets	2.93	2.91	2.95	2.74	2.96	2.85	2.98	2.86
56.7. ancient astronomy	2.41	2.23	2.39	2.11	2.38	2.24	2.38	2.27

	Geographic Region				Sex		Teaching Experience	
	NE	C	S	FW	F	M	≤6 yrs	>6 yrs
VI. **THE EARTH IN SPACE** (cont.)								
C. **Stars**								
57. *Understand the characteristics of stars and the processes that occur within them*	3.00	3.00	3.05	2.93	3.05	2.97	2.98	3.02
57.1. properties of stars (e.g., mass, spectral class, magnitude)	2.79	2.78	2.79	2.71	2.83	2.74	2.80	2.78
57.2. relative distances and velocities (e.g., parallax, Doppler shift)	2.80	2.73	2.68	2.68	2.74	2.71	2.75	2.74
57.3. stages in the life cycles of stars (e.g., nebula, main sequence, giants, dwarfs, black holes)	2.88	2.87	2.81	2.75	2.91	2.79	2.86	2.85
57.4. H-R diagram	2.69	2.49	2.56	2.56	2.59	2.57	2.58	2.61
58. *Understand the interrelationships between civilization and astronomical objects*	2.73	2.78	2.84	2.54	2.90	2.64	2.65	2.74
58.1. constellations and star charts	2.57	2.53	2.65	2.30	2.70	2.43	2.51	2.51
58.2. space exploration	2.84	3.03	2.82	2.65	3.02	2.77	2.87	2.85
58.3. planetariums	2.44	2.48	2.60	2.23	2.65	2.35	2.51	2.40
D. **Galaxies and the Universe**								
59. *Understand the structure of the Milky Way and other galaxies*	2.84	2.86	2.97	2.83	2.94	2.84	2.90	2.89
59.1. multiple star systems (e.g., binaries, clusters)	2.56	2.58	2.52	2.44	2.66	2.47	2.55	2.54
59.2. characteristics of galaxies	2.69	2.70	2.76	2.60	2.76	2.65	2.77	2.69
59.3. relative distances and motions of objects in the universe	2.89	2.84	2.79	2.66	2.83	2.78	2.76	2.84
59.4. quasars	2.51	2.35	2.42	2.27	2.46	2.36	2.44	2.39
59.5. structure of the universe (e.g., curvature, gravitational/time relationship)	2.67	2.39	2.65	2.54	2.59	2.55	2.56	2.57
59.6. hypotheses of the origin and evolution of the universe	3.06	2.85	2.97	2.91	3.09	2.89	3.02	2.93

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